US006561751B1

(12) **United States Patent**
Ishizaki et al.

(10) **Patent No.: US 6,561,751 B1**
(45) **Date of Patent: May 13, 2003**

(54) **ACTUATOR CONTROL DEVICE AND BUCKET POSTURE CONTROL DEVICE FOR HYDRAULIC DRIVE MACHINE**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 58 days.

(21) Appl. No.: **09/666,138**

(22) Filed: **Sep. 20, 2000**

(30) **Foreign Application Priority Data**

Sep. 21, 1999 (JP) 11-267134

(51) **Int. Cl.**[7] **B66F 9/00**
(52) **U.S. Cl.** **414/700**; 91/520
(58) **Field of Search** 414/700, 708, 414/699; 91/508, 511, 517, 520, 361, 459

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,799,851 A * 1/1989 Swanson 414/700
5,447,094 A * 9/1995 Geyler, Jr. .... 414/700 X
5,669,282 A * 9/1997 Tanino et al. .... 414/700 X

* cited by examiner

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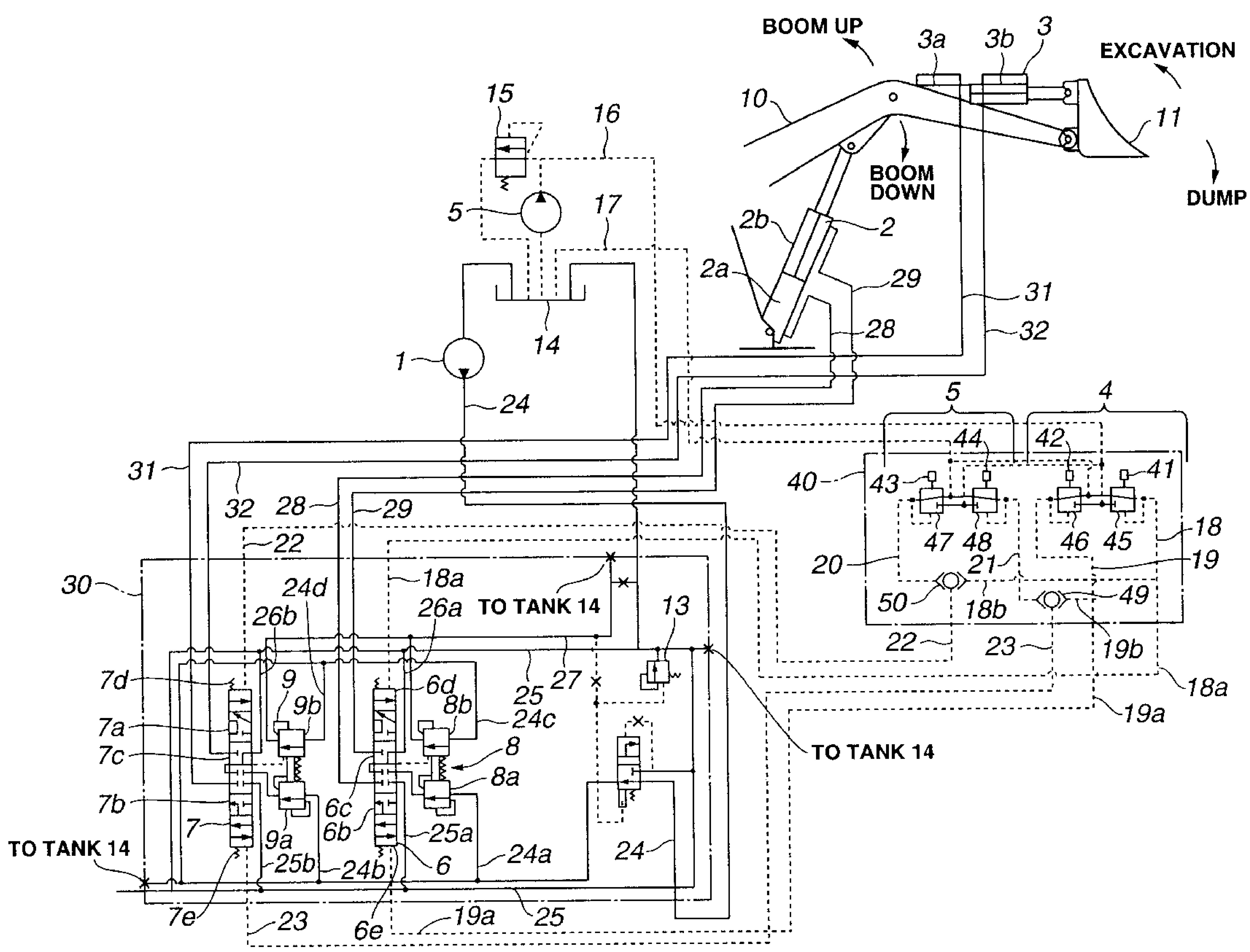
(57) **ABSTRACT**

A high versatility can be obtained, the pipe laying can be configured easily and, by virtue of the fact that a pilot pressured oil is managed, a hydraulic apparatus can be compacted. A differential pressure ΔP between a pressure of the pressured oil on an upstream side and a pressure of the pressured oil on a downward side of operation valves is set to a certain value by a front-to-rear differential pressure stabilizer. As a result, flow rates Q1, Q2 of the operation valves are determined univocally in accordance with opening surface areas (opening amounts) A1, A2 of the operation valves, irrespective of load fluctuations, that is to say, a fluctuation of ΔP. When one of operation members are operated, the opening amount A2 of the other operation valve correspondent with the other operation member is changed in accordance with an operation amount S1 of that operation member, and the other hydraulic actuator correspondent with the other operation valve is driven.

5 Claims, 6 Drawing Sheets



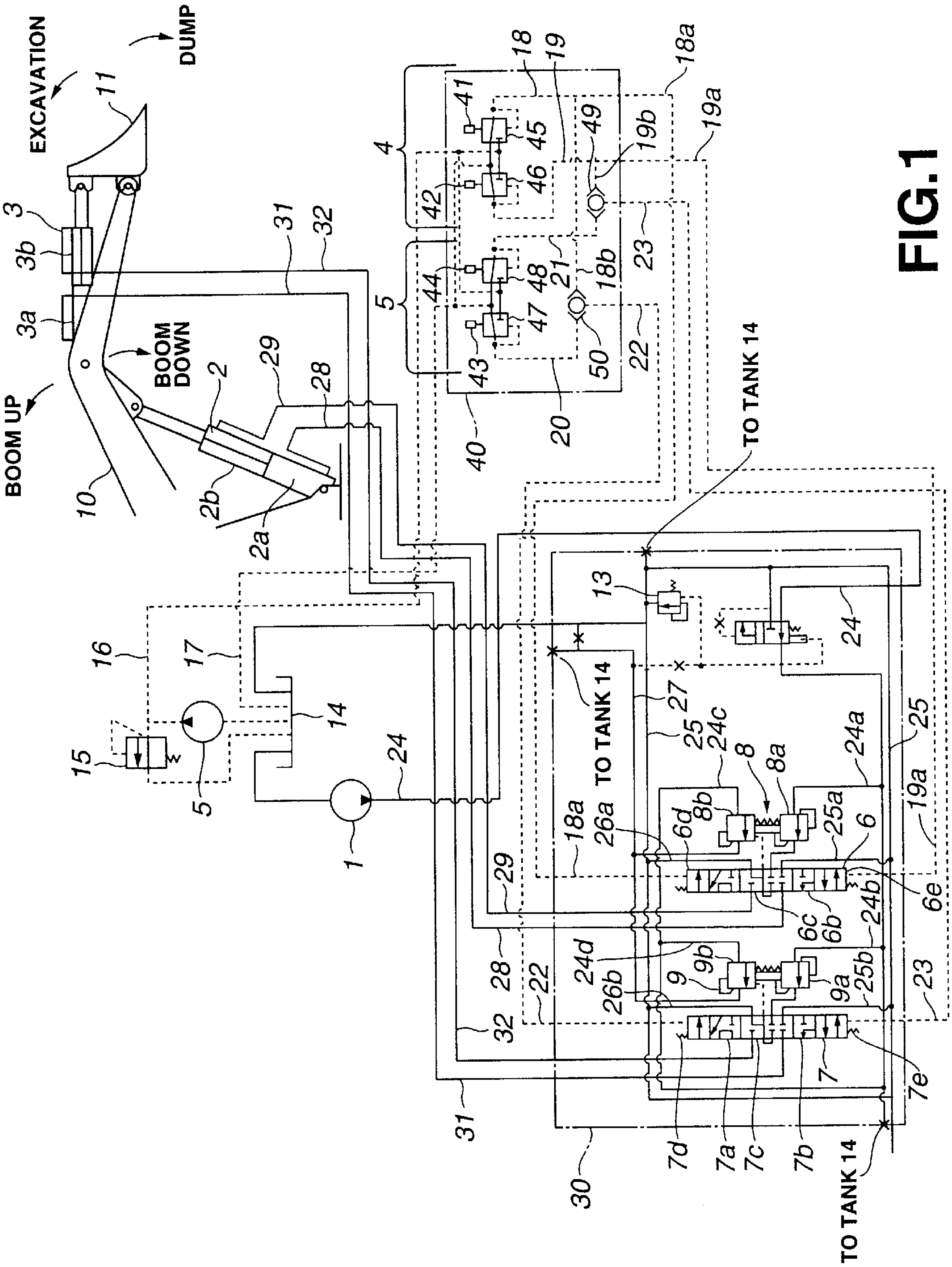
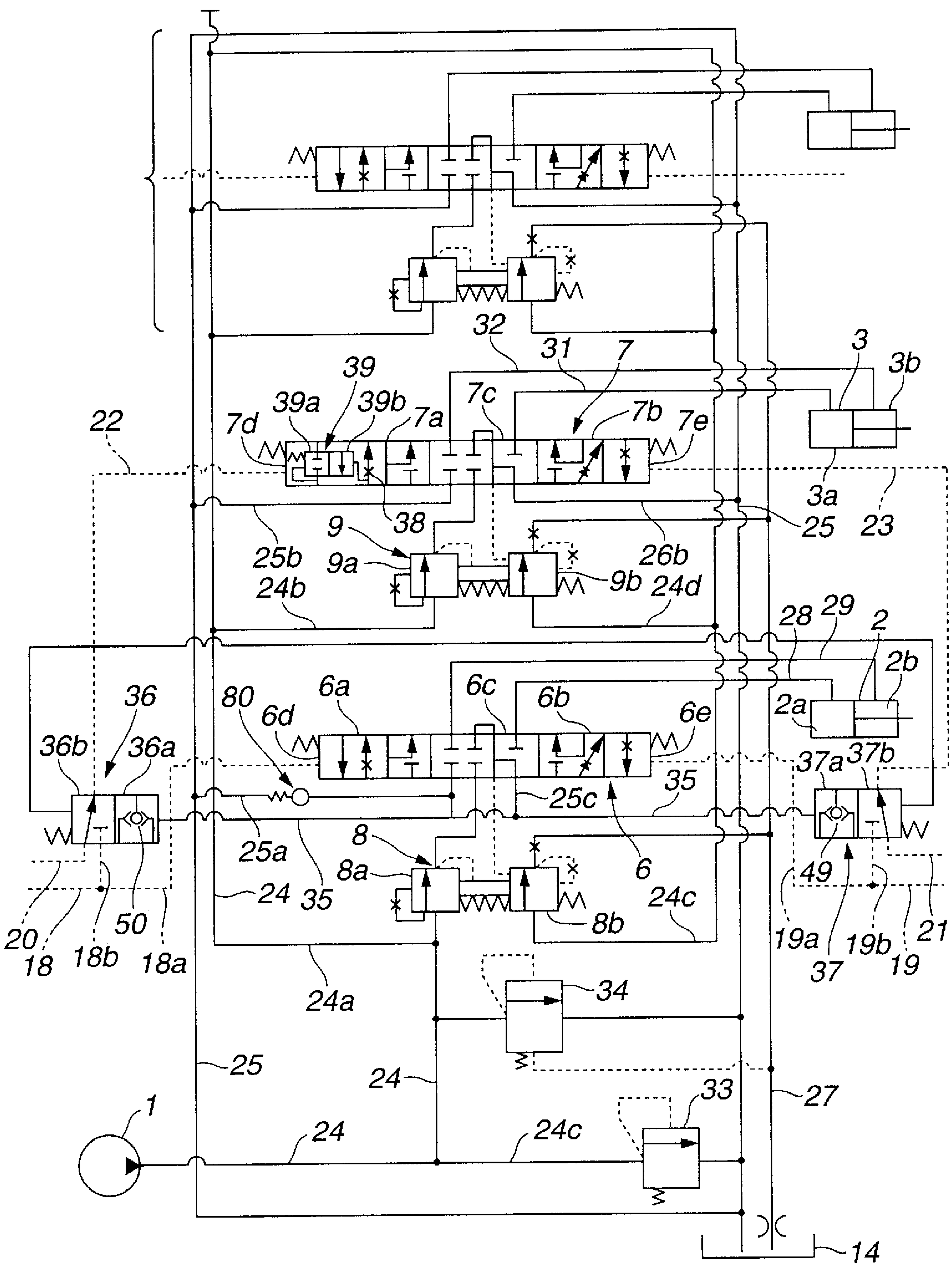

EXCAVATION
DUMP
BOOM UP
BOOM DOWN
TO TANK 14
TO TANK 14
TO TANK 14

FIG.1



1
2
2a
2b
3
3a
3b
6
6a
6b
6c
6d
6e
7
7a
7b
7c
7d
7e
8
8a
8b
9
9a
9b
14
18
18a
18b
19
19a
19b
20
21
22
23
24
24a
24b
24c
24d
25
25a
25b
25c
26b
27
28
29
31
32
33
34
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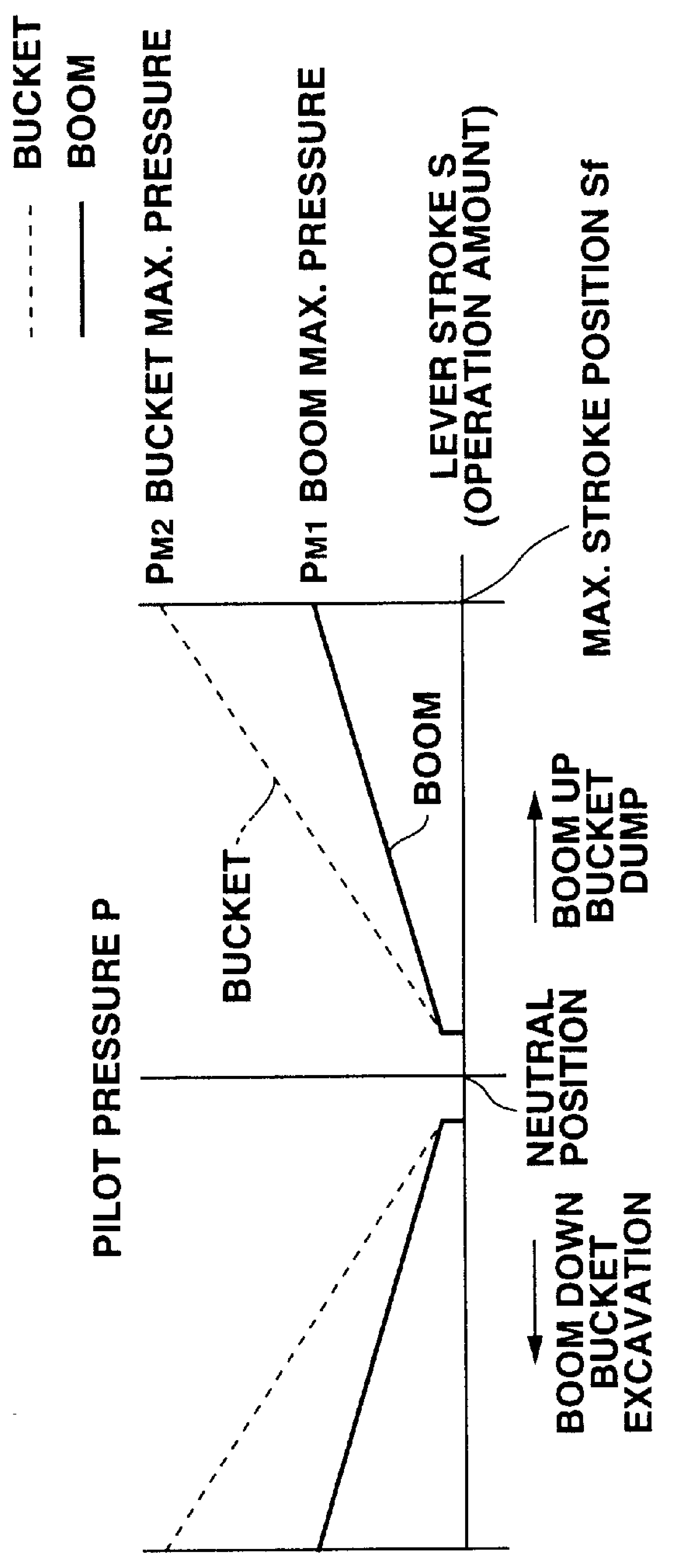
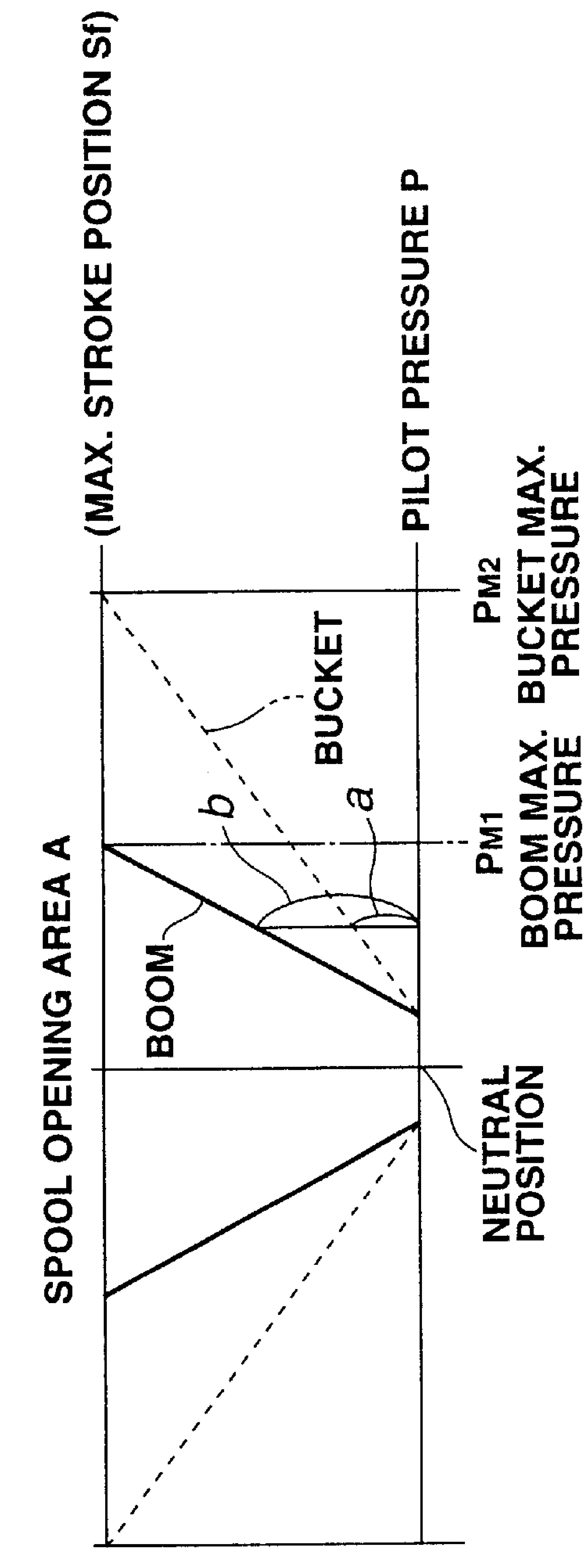
36a
36b
37
37a
37b
38
39
39a
39b
49
50
80

FIG.2



BUCKET
BOOM
PM2 BUCKET MAX. PRESSURE
PM1 BOOM MAX. PRESURE
LEVER STROKE S (OPERATION AMOUNT)
MAX. STROKE POSITION Sf
PILOT PRESSURE P
BUCKET
BOOM
NEUTRAL POSITION
BOOM UP BUCKET DUMP
BOOM DOWN BUCKET EXCAVATION

FIG.3(a)



(MAX. STROKE POSITION Sf)
PILOT PRESSURE P
SPOOL OPENING AREA A
BUCKET
b
a
BOOM
PM2 BUCKET MAX. PRESSURE
PM1 BOOM MAX. PRESSURE
NEUTRAL POSITION

FIG.3(b)

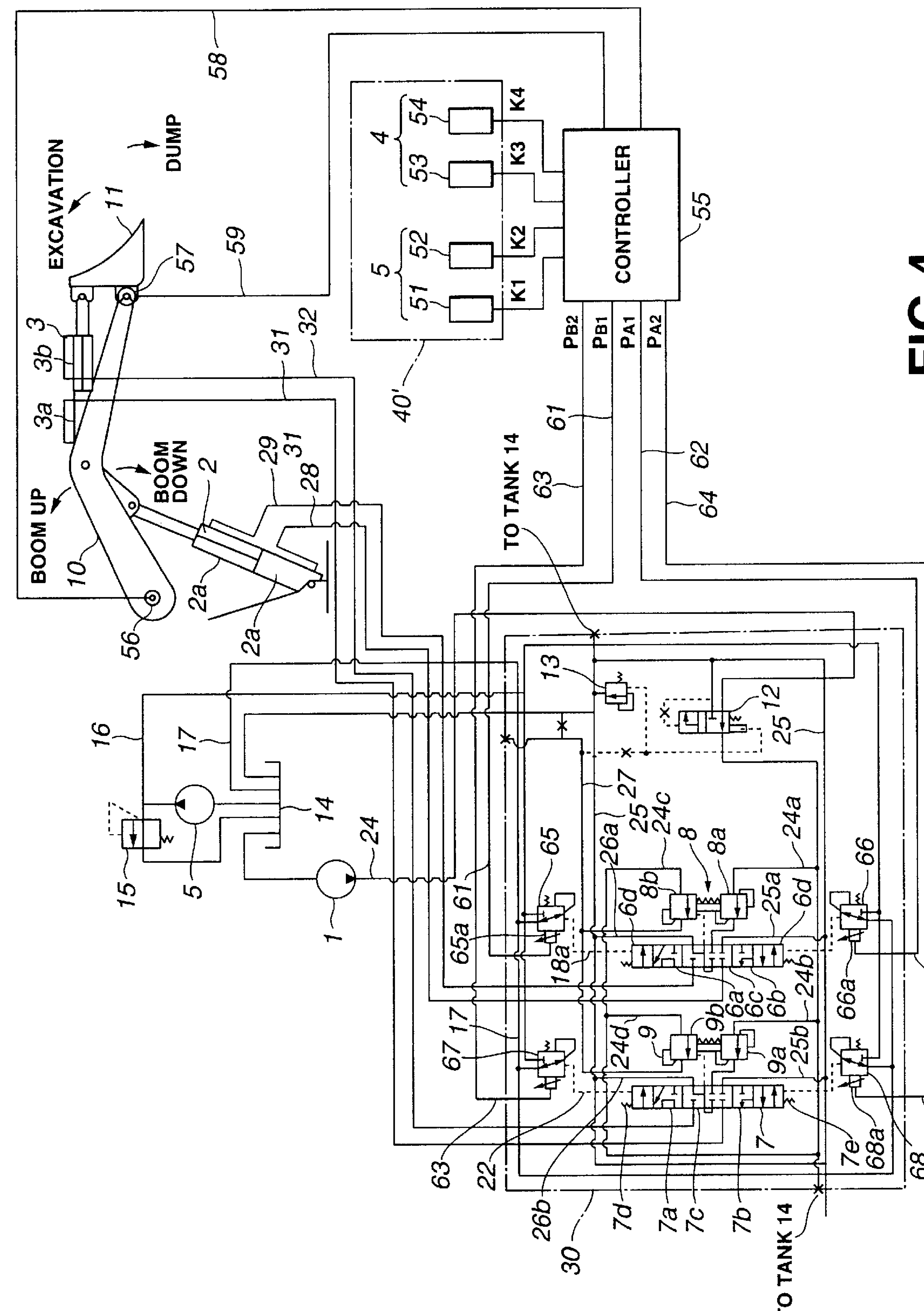

EXCAVATION
DUMP
BOOM UP
BOOM DOWN
CONTROLLER
K1
K2
K3
K4
PB2
PB1
PA1
PA2
TO TANK 14
TO TANK 14

FIG.4

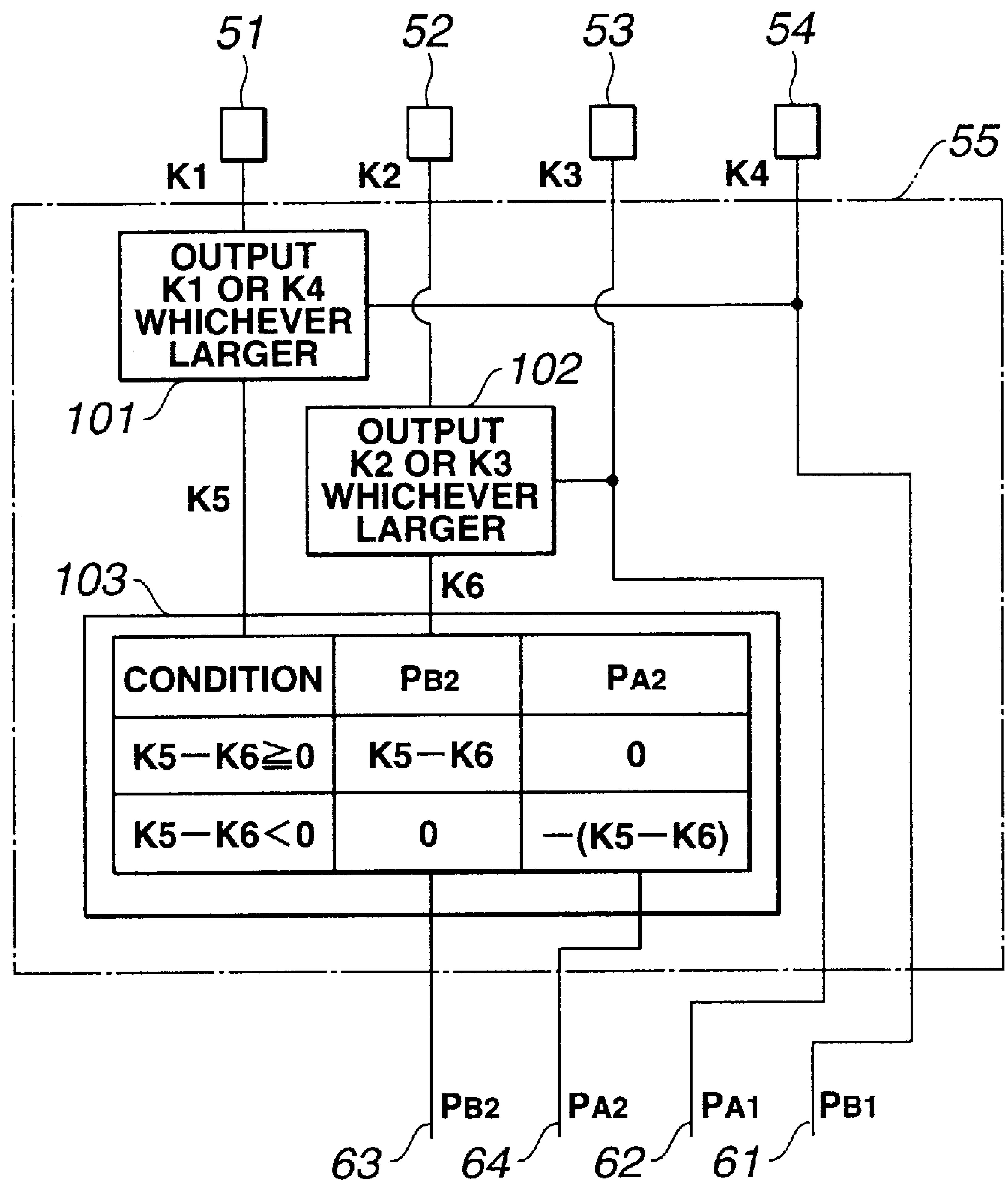

51
52
53
54
55
K1
K2
K3
K4
OUTPUT K1 OR K4 WHICHEVER LARGER
101
102
OUTPUT K2 OR K3 WHICHEVER LARGER
K5
K6
103
CONDITION
PB2
PA2
K5−K6≧0
K5−K6
0
K5−K6<0
0
−(K5−K6)
PB2
PA2
PA1
PB1
63
64
62
61

FIG.5(a)

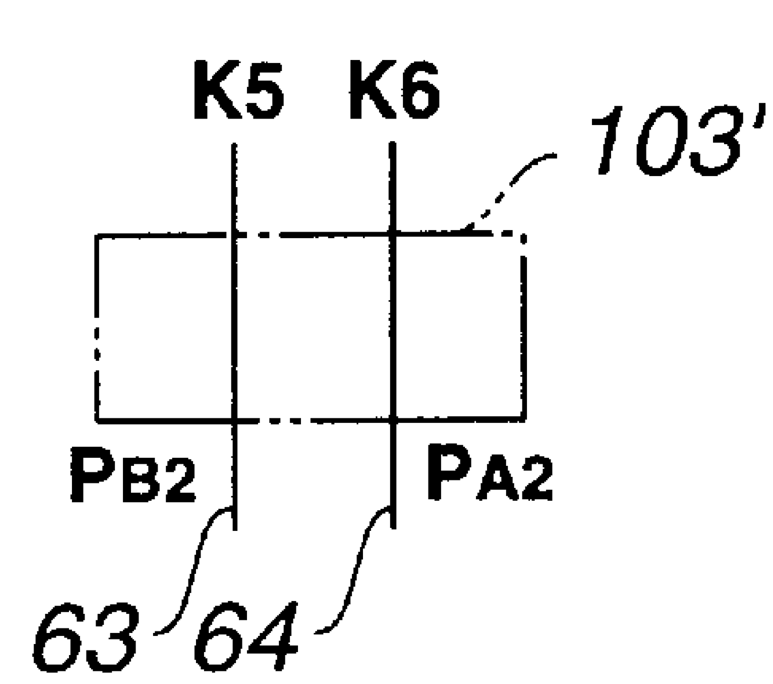

K5
K6
103'
PB2
PA2
63
64

FIG.5(b)

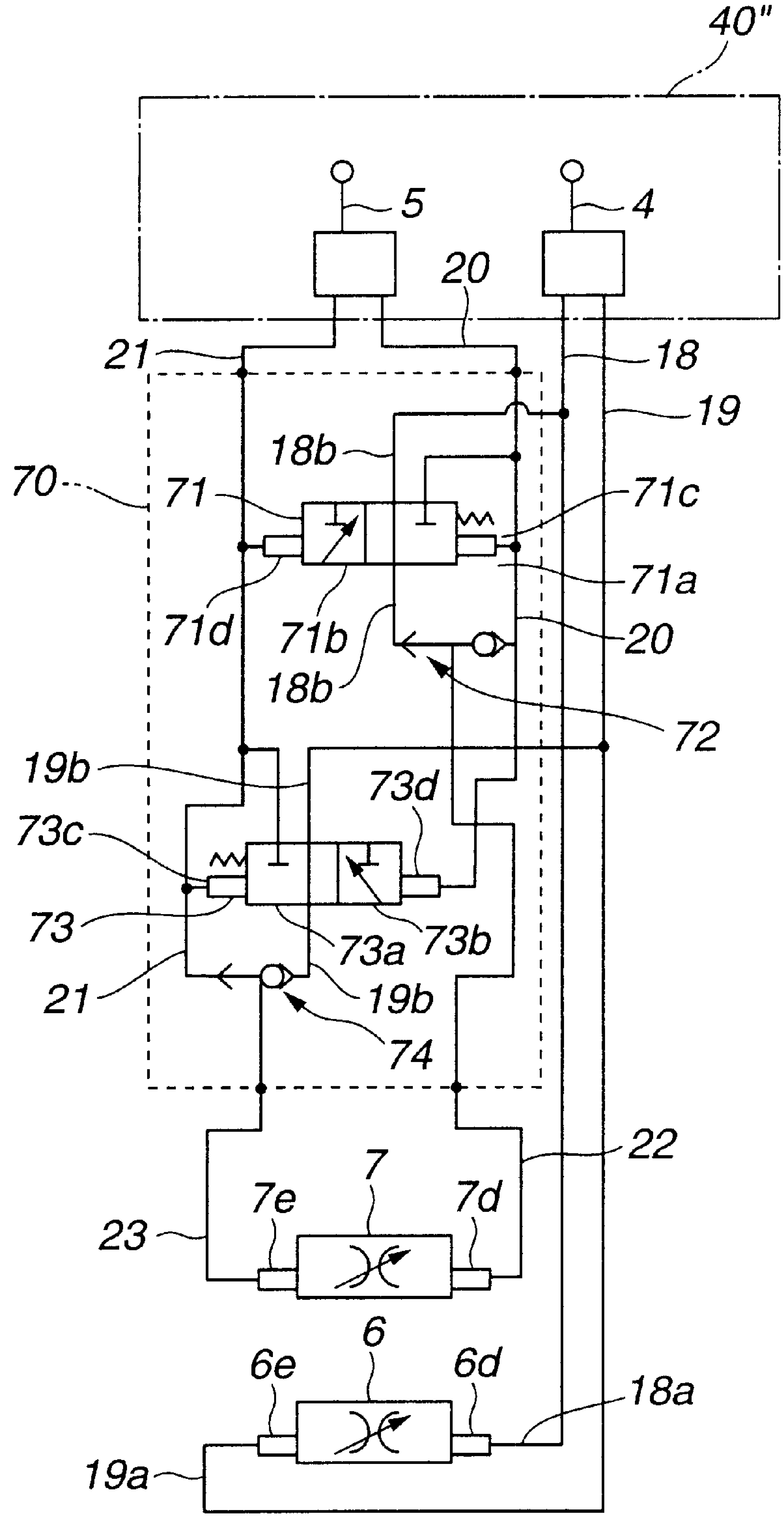

40"
5
4
20
21
18
19
18b
70
71
71c
71a
71d
71b
20
18b
72
19b
73d
73c
73
73a
73b
21
19b
74
22
7
7e
7d
23
6
6e
6d
18a
19a

FIG.6

ACTUATOR CONTROL DEVICE AND BUCKET POSTURE CONTROL DEVICE FOR HYDRAULIC DRIVE MACHINE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a device which performs the drive control of two hydraulic actuators. In addition, the present invention relates to a device which performs the drive control of a boom hydraulic actuator and a bucket hydraulic actuator such that a posture of the bucket provided in the hydraulic drive machine is held constant.

2. Description of the Related Art

Booms and buckets are provided as work devices in construction machine such as wheel loaders and skid-stair loaders and so on.

By way of example, using a wheel loader, work is performed in which, following the excavation of the earth and sand with the bucket, the boom is raised whereby the earth and sand within the bucket is loaded into a dump truck. For the boom to be actuated in the upward direction during this work operation, the bucket must be actuated in the dumping direction in such a way that the posture of the bucket is held in a constant horizontal state with respect to the ground surface. This horizontal hold control is indispensable in preventing the earth and sand and so on within the bucket from spilling.

However, when the above-noted horizontal hold control is entrusted to the manual operation of the operator only, the dual operation of a boom operation unit and bucket operation unit must be performed. This dual operation places a large burden on the operator and requires experience. For this reason, an invention in which the abovementioned horizontal hold control can be performed without burden on the operator, and for which no experience is required, has been hitherto well known. That is to say, an invention in which the boom and the bucket are simultaneously actuated by the boom operation unit to perform horizontal hold control has been hitherto well known.

By way of example, an invention in which the boom and arm of a wheel loader are linked by a linking mechanism and, the posture of the bucket is held horizontal by the actuation of the bucket at a constant relationship established by the link mechanism in response to the actuation of the boom has been hitherto well known.

However, according to this invention, a special link mechanism must be manufactured in accordance with the type of work device. In addition, the link mechanism cannot be installed easily in existing construction machine and new work devices must be manufactured. For this reason, there are problems in that this lacks versatility.

In addition, Japanese Patent Application Laid-Open No. 10-219730 describes an invention in which return pressured oil discharged from a boom hydraulic cylinder is, in such a way that the posture of the bucket is held horizontal, branched by a branching valve to be supplied to a bucket hydraulic cylinder.

However, the abovementioned branching valve must be provided between an operation valve and the hydraulic cylinder. For this reason, the laying of the pressured oil conduits is complicated. In addition, a problem arises in that the hydraulic apparatus, through which a large flow rate of pressured oil of high pressure passes, is of large scale. In addition, because the flow rate which drives the actuator is

branched, changes in the flow rate are dependent on the load. For this reason the operator must, to maintain the horizontal posture, be constantly carrying out minute operations. In other words, there are the problems that, because control is difficult, the burden on the operator is large and experience is required.

SUMMARY OF THE INVENTION

Thereupon, the present invention, which has excellent versatility, in which the pipe laying can be configured easily, in which the hydraulic apparatus can be compacted by the manipulation of pilot pressured oil, and in which no burden is placed on the operator, was designed to resolve these problems.

A first invention of the present inventions provides, in order to achieve the above-noted resolution of the problems, a hydraulic drive machine which comprises: a hydraulic pump (**1**), and at least two hydraulic actuators (**2, 3**) driven by supply of discharged pressured oil from the hydraulic pump (**1**); operation means (**4, 5**) provided correspondent with the hydraulic actuators (**2, 3**); and operation valves (**6, 7**) connected between each of the operation means and each of its correspondent hydraulic actuator which respectively change opening amounts thereof in accordance with operating amounts of the operation means (**4, 5**), and which supply pressured oil to the hydraulic actuators (**2, 3**) correspondent with the operation means (**4, 5**), at a flow rate according to the respective opening amounts, wherein

the machine comprises front-to-rear differential pressure constant means (**8, 9**) connected between the hydraulic pump and each of the operational valves which equalize a difference in pressure between a pressure of pressured oil on an upstream side and a pressure of pressured oil on a downstream side of the operation valves (**6, 7**) respectively, and wherein

when one of the operation means (**4**) of the operation means (**4, 5**) is operated, by changing the opening amount of the other operation valve (**7**) correspondent with the other operation means (**5**) in accordance with the operation amount of the operation means (**4**), the other hydraulic actuator (**3**) correspondent with the other operation valve (**7**) is driven.

A description of the first invention is given below with reference to FIG. **1** and FIG. **3**.

Based on the general formula for a hydraulic circuit, the following formula (1) is established, when Q is the flow rate which passes through the diaphragm of the operation valve, c is the flow rate coefficient, A is the opening surface area of the diaphragm, and ΔP is the front-to-rear differential pressure of the diaphragm

$$Q=c\cdot A\cdot\sqrt{\Delta P}) \tag{1}$$

Here, by constantly making the differential pressure ΔP identical, a flow rate is obtained which is proportional to a drive command value (opening surface area A) issued by the operator.

According to the first invention, the differential pressure ΔP between the pressure of the pressured oil on the upstream side and the pressure of the pressured oil on the downstream side of the operation valves **6, 7** is equalized by the front-to-rear differential pressure constant means **8, 9**. As a result, from the above-noted formula (1), the flow rates Q**1**, Q**2** of the operation valves **6, 7** are, irrespective of load fluctuations, determined univocally in accordance with the opening surface areas (opening amounts) A**1**, A**2** of the operation valves **6, 7**.

When one of the operation means **4**, **5**, the operation means **4** for example is operated, the opening amount A2 of the other operation valve **7** correspondent with the other operation means **5** is altered in accordance with the operation amount S1 of said operation means **4**, and the other hydraulic cylinder **3** correspondent with said other operation valve **7** is driven.

That is to say, the ratio of the opening amount A1 of the operation valve **6** and the opening amount A2 of the operation valve **7** with respect to the operation amount S1 of the one operation means **4** is, as shown in FIG. **3**(*b*), set to a constant relationship (b:a). For this reason, the ratio of the flow rate Q1 supplied to the hydraulic cylinder **2** correspondent with the operation valve **6**, and the flow rate Q2 supplied to the hydraulic cylinder **3** correspondent with the operation valve **7**, form the above-noted constant relationship (b:a).

According to the first invention as described above, by way of example, a boom hydraulic cylinder **2** and bucket hydraulic cylinder **3** can be simultaneously driven at a constant flow rate ratio by the operation of the boom operation unit **4** only.

In this case, since the ratio of the opening amount A1 of the operation valve **6** and the opening amount A2 of the operation valve **7** with respect to the operation amount S1 of the operation means **4** only needs to be set to a constant relationship, the device configuration, such as the laying of the pressured oil conduits, is simple. That is to say, for example, a shuttle valve **50** and a pilot conduit **18***b* only should be newly provided such that a pilot pressure P in accordance with the operation amount S1 can be supplied to the operation valves **6**, **7**. In addition, the operation valves **6**, **7** (the spool) should be configured in such a way that the ratio of the opening amounts A1, A2 of the operation valves **6**, **7** form a constant relationship.

In addition, according to the first invention, the shuttle valve **50** and the pilot conduit **18***b* only are newly provided, and the operation valves **6**, **7** (the spool thereof) only needs to be configured such that the ratio of the opening amount A2 of the operation valve **7** and the opening amount A1 of the operation valve **6** with respect to the operation amount S1 of the boom operation unit **4** is set to a constant relationship. For this reason, it can be easily installed in existing hydraulic circuits.

In addition, according to the first invention, the pilot pressured oil of low pressure and small flow rate is used, so the hydraulic apparatus can be compacted.

As a result, according to the first invention, high versatility can be obtained, the pipe laying can be configured easily and, by virtue of the fact that the pilot pressured oil is managed, the hydraulic apparatus can be compacted.

In addition a second invention provides a hydraulic drive machine which comprises: a hydraulic pump (**1**), and a boom hydraulic actuator (**2**) and a bucket hydraulic actuator (**3**) driven by supply of discharged pressured oil from the hydraulic pump (**1**); a boom (**10**) and a bucket (**11**) operated in accordance with the drive of the boom hydraulic actuator (**2**) and the bucket hydraulic actuator (**3**) respectively; boom operation means (**4**) and bucket operation means (**5**) provided correspondent with the boom hydraulic actuator (**2**) and the bucket hydraulic actuator (**3**) respectively; and a boom operation valve (**6**) and a bucket operation valve (**7**) which change opening amounts thereof in accordance with operating amounts of the boom operation means (**4**) and the bucket operation means (**5**), and which supply pressured oil to the boom hydraulic actuator (**2**) and the bucket hydraulic actuator (**3**) respectively, at a flow rate in accordance with the respective opening amounts, wherein the machine comprises: front-to-rear differential pressure constant means (**8**, **9**) connected between the hydraulic pump and each of the operational valves which equalize a difference in pressure between a pressure of pressured oil on an upstream side and a pressure of pressured oil on a downstream side of the boom operation valve (**6**) and the bucket operation valve (**7**) respectively; and, control means (**50**, **49**) which, when the boom operation means (**4**) is operated, changes an opening amount of the bucket operation valve (**7**) in response to the operation amount of the boom operation means (**4**) in such a way that a posture of the bucket (**11**) is held constant.

A description of the second invention is given below with reference to FIG. **1** and FIG. **3**.

According to the second invention, the differential pressure ΔP between the pressure of the pressured oil on the upstream side and the pressure of the pressured oil on the downstream side of the operation valves **6**, **7** is made identical by the front-to-rear differential pressure constant means **8**, **9**. As a result, from the above-noted formula (1)($Q=c\cdot A\cdot\sqrt{(\Delta P)}$), the flow rates Q1, Q2 of the operation valves **6**, **7** are determined univocally, irrespective of load fluctuations, that is to say, fluctuations in ΔP, in accordance with the opening surface areas (opening amounts) A1, A2 of the operation valves **6**, **7**.

When the boom operation means **4** is operated, the opening amount A2 of the bucket operation valve **7** alters in response to the operation amount S1 of the boom operation means **4** in such a way that the posture of the bucket **11** is held constant.

That is to say, the ratio of the opening amount A1 of the operation valve **6** and the opening amount A2 of the operation valve **7** with respect to the operation amount S1 of the boom operation means **4** is, as shown in FIG. **3**(*b*), set to a fixed relationship (b:a). By virtue of this, the ratio of the flow rate Q1 supplied to the boom hydraulic cylinder **2** correspondent with the boom operation valve **6** and the flow rate Q2 supplied to the bucket hydraulic cylinder **3** correspondent with the bucket operation valve **7** is the above-noted constant relationship (b:a). As a result, the posture of the bucket **11** is held constant.

According to the second invention, as described above, the bucket hydraulic cylinder **3** and the boom hydraulic cylinder **2** can be simultaneously driven at a constant flow rate ratio by only the operation of the boom operation means **4**, and the posture of the bucket **11** can be set constant.

In this case, since the ratio of the opening amount A1 of the boom operation valve **6** and the opening amount A2 of the bucket operation valve **7** with respect to the operation amount S1 of the boom operation means **4** only needs to be set to a constant relationship, the device configuration such as the laying of the pressured oil conduits is simple. That is to say, for example, a shuttle valve **50** and a pilot conduit **18***b* only should be newly provided such that the pilot pressure P can be supplied to the operation valves **6**, **7** in accordance with the operation amount S1. In addition, the operation valves **6**, **7** (the spool thereof) should be configured in such a way that the ratio of the opening amounts A1, A2 of the operation valves **6**, **7** form a constant relationship.

In addition, according to the second invention, the shuttle valve **50** and the pilot conduit **18***b* only should be newly provided, and the operation valves **6**, **7** (the spool thereof) need only to be configured in such a way that the ratio of the A2 of the operation valve **7** and the opening amount A1 of the operation valve **6** with respect to the operation amount S1 of the boom operation means **4** is set to a constant relationship. For this reason, it can be installed easily in existing hydraulic circuits.

In addition, according to the second invention, since the pilot pressured oil, of low pressure and small flow rate, is used, the hydraulic apparatus can be compacted.

As a result, according to the second invention, a high versatility can be obtained, the pipe laying can be configured easily and, by the management of the pilot pressured oil, the hydraulic apparatus can be compacted.

In addition, a third invention is characterized in that, in the second invention the control means **(50, 49)**, when a boom operation signal is output from the boom operation means **(4)** to afford a lift operation of the boom **(10)**, generates a bucket operation signal which affords the actuation of the bucket **(11)** in a dumping direction in response to the boom operation signal, and changes the opening amount of the bucket operation valve **(7)** in response to the bucket operation signal.

A description of the third invention is given below with reference to FIG. **1**.

According to the third invention, when a boom operation signal is emitted from the abovementioned boom operation means **4** to afford the lift operation of the abovementioned boom **10**, a bucket operation signal is generated which affords the actuation of the abovementioned bucket **11** in the dumping direction in response to said boom operation signal, and the opening amount A2 of the abovementioned bucket operation valve **7** is altered in accordance with said bucket operation signal.

According to the third invention, automatic actuation in the dumping direction to the bucket **11** is performed by the operation of the boom operation means **4** in such a way that the boom **10** is lift-actuated, whereby the posture of the bucket **11** can be held constant.

In addition, the fourth invention is characterized in that, in the second invention, stroke stoppage detection means **(35)** which is connected to the boom operation valve and detects the stroke stoppage of the boom hydraulic actuator **(2)** is further provided, and wherein, when the stroke stoppage of the hydraulic actuator **(2)** has been detected by the stroke stoppage detection means **(35)**, the control by the control means **(50, 49)** is turned off.

A description is given below of the fourth invention with reference to FIG. **2**.

According to the fourth invention, when the stroke stoppage of the boom hydraulic cylinder **2** has been detected by the stroke stoppage detection means **35**, and when control is performed by the control means **50, 49**, in other words, the boom operation means **4** has been operated, the control which alters the opening amount A2 of the bucket operation valve **7** in response to the operation amount S1 of the boom operation means **4** is switched OFF in such a way that the posture of the bucket **11** is held constant.

According to the fourth invention, the same effects as the second invention are obtained.

Further according to the fourth invention, it can be prevented that the posture of the bucket **11** is not held constant by the continued supply of the pressured oil to the bucket hydraulic cylinder **3** following the stroke stoppage of the boom hydraulic cylinder **2**.

That is to say, the control by the control means **50, 49** constitutes a control whereby a flow rate of pressured oil, in accordance with the operation amount S1, is supplied to the boom hydraulic cylinder **2** and bucket hydraulic cylinder **3** in response to the operation of the boom operation means **4**. For this reason, even following the stroke stoppage of the boom hydraulic cylinder **2** and the stoppage of the operation of the boom **10**, as long as the boom operation means **4** is operated, the supply of the flow rate of pressured oil to the bucket hydraulic cylinder **3** in accordance with the operation amount S1 thereof will be continued and the bucket **11** will continue to be actuated. For this reason, the posture of the bucket **11** will not remain constant.

Thereupon, in the fourth invention, when the stroke stoppage of the boom hydraulic cylinder **2** is detected by the stroke stoppage detection means **35**, the supply to the bucket hydraulic cylinder **3** of the pressured oil at a flow rate in accordance with the operation amount S1 of the boom operation means **4**, is stopped. More specifically, a flow rate of pressured oil, in accordance with the operation amount S2 of the bucket operation means **5**, is supplied to the bucket hydraulic cylinder **3**. For this reason, as soon as the operation of the boom **10** is stopped, the actuation of the bucket **11** becomes dependent on the operation amount S2 of the bucket operation means **5**. By virtue of this, when the operation amount S2 of the bucket operation means **5** is 0, the posture of the bucket **11** is held constant.

In addition, a fifth invention is characterized in that, in the second invention, it further comprises exhaust flow rate control means **(39)** that is connected to the bucket operation valve for controlling a flow rate of pressured oil exhausted from the bucket hydraulic actuator **(3)** in response to a pressure of pressured oil supplied to the bucket hydraulic actuator **(3)**, in such a way that a posture of the bucket is held constant.

A description is given below of the fifth invention with reference to FIG. **2**.

According to the fifth invention, the same effects as the second invention are obtained.

Further, according to the fifth invention, the actuation of the bucket **11** by its own weight and displacement from the constant posture of the bucket **11** can be prevented.

That is to say, when the bucket **11** is actuated by its own weight and not by the pressured oil supplied from the hydraulic pump **1**, displacement of the constant posture of the bucket **11** occurs.

Therefore, according to the fifth invention, if the pressured oil from the hydraulic pump **1** is supplied to the bucket hydraulic cylinder **3** and the pressure of the pressured oil is above a constant value, the flow rate of the pressured oil exhausted from the bucket hydraulic cylinder **3** is, without control, exhausted to a tank **23**. In addition, when the pressured oil from the hydraulic pump **1** is not supplied to the bucket hydraulic cylinder **3** and the pressure of the pressured oil exceeds a constant value, the flow rate of the pressured oil exhausted from the bucket hydraulic cylinder **3** is controlled. By virtue of this, the actuation of the bucket **11** by its own weight is prevented. As a result, the actuation by its own weight and displacement from the constant posture of the bucket **11** is prevented.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a hydraulic circuit diagram of a first embodiment;

FIG. **2** is a hydraulic circuit diagram of a second embodiment;

FIGS. **3**(*a*) and (*b*) are diagrams which describe the relationship between the operation amount of the operation lever and the opening surface area of the operation valve;

FIG. **4** is a hydraulic circuit diagram of a third embodiment;

FIGS. **5**(*a*), (*b*) are diagrams which show the process details of the control implemented by the controller shown in FIG. **4**; and

FIG. **6** is a hydraulic circuit diagram of a fourth embodiment.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

A description of an embodiment of the actuator control device and bucket posture control device pertaining to the present invention is given below with reference to the diagrams.

It will be noted that the embodiments hypothesize a hydraulic circuit mounted in construction machine such as a wheel loader or skid stair loader. In such construction machines a boom and bucket are provided as the work devices.

FIG. **1** shows the hydraulic circuit of a first embodiment.

The main hydraulic pump **1** shown in FIG. **1**, which is driven by an engine not shown in the diagram, discharges pressured oil. The discharged pressured oil is supplied to an operation valve unit **30** by way of a conduit **24**. In addition, a pilot hydraulic pump **5**, which is driven by the abovementioned engine, discharges pilot pressured oil. The pilot pressured oil is supplied to an operation lever device **40** by way of a conduit **16**. A relief valve **15**, which controls the pressure of the pilot pressured oil discharged into the conduit **16** from the pilot pressured oil pump **2** so it is less than a set relief pressure, is connected to the conduit **16**. The return pressured oil is exhausted to a tank **14**.

The pressured oil of pilot pressure P, in accordance with an operation amount S1 of a boom operation means **4**, and the pressured oil of pilot pressure P, in accordance with an operation amount S2 of a bucket operation means **5**, are output from the operation lever device **40**.

A boom operation valve **6**, correspondent with the boom operation means **4**, is provided in the operation valve unit **30**. In addition, a bucket operation valve **7** is provided correspondent with the bucket operation means **5**.

A boom hydraulic cylinder **2** and a bucket hydraulic cylinder **3** are respectively driven by the supply of the discharged pressured oil of the main hydraulic pump **1** by way of a boom operation valve **6** and a bucket operation valve **7**. A rod of the boom hydraulic cylinder **2** and a rod of the bucket hydraulic cylinder **3** are respectively connected to a boom **10** and bucket **11**. The bucket **11** is interlocked to the boom **10**.

The boom hydraulic cylinder **2** comprises a bottom chamber **2*a*** and a head chamber **2*b***. When the pressured oil is supplied from the boom operation valve **6** by way of a conduit **28** to the bottom chamber **2*a*** of the boom hydraulic cylinder **2**, the rod of the boom hydraulic cylinder **2** is extended and the boom **10** is actuated to the lifting side. In addition, when the pressured oil is supplied from the boom operation valve **6** by way of a conduit **29** to the head chamber **2*b*** of the boom hydraulic cylinder **2**, the rod of the boom hydraulic cylinder **2** is retracted and the boom **10** is actuated to the lower side.

The bucket hydraulic cylinder **3** comprises a bottom chamber **3*a*** and head chamber **3*b***. When the pressured oil is supplied from the bucket operation valve **7** by way of a conduit **31** to the bottom chamber **3*a*** of the bucket hydraulic cylinder **3**, the rod of the bucket hydraulic cylinder **3** is extended and the bucket **11** is actuated to the dump side. In addition, when the pressured oil is supplied from the bucket operation valve **7** by way of a conduit **32** to the head chamber **3*b*** of the bucket hydraulic cylinder **3**, the rod of the bucket hydraulic cylinder **3** is retracted and the bucket **11** is actuated to the excavation side.

Pressure compensation valves **8**, **9** are provided in the operation valve unit **30** for each operation valve **6**, **7**.

The pressure compensation valve **8** is provided, from the perspective of the main hydraulic pump **1**, in the upstream side of the boom operation valve **6**, in other words, on a pressured oil supply channel between the main hydraulic pump **1** and the boom operation valve **6**. In the same way, the pressure compensation valve **9** is provided, from the perspective of the main hydraulic pump **1**, in the upstream side of the bucket operation valve **7**, in other words, on a pressured oil supply channel between the main hydraulic pump **1** and the bucket operation valve **7**.

The pressure compensation valves **8**, **9** are valves which equalize the difference in pressure between the pressure of the pressured oil on the downstream side and the pressure of the pressured oil on the upstream side of the operation valves **6**, **7**. As is deduced from the above-noted formula (1) ($Q=c\cdot A\cdot\sqrt{(\Delta P)}$), which constitutes a general formula for a hydraulic circuit, by the equalizing of the differential pressure ΔP, a flow rate Q1 is obtained which is proportionate to the operation amount S1 (opening surface area A1 of the operation valve **6**) of the operation unit **4** operated by the operator and which bears no relationship to the magnitude of the load. In the same way, a flow rate Q2 is obtained which is proportionate to the operation amount S2 (opening surface area A2 of the operation valve **7**) of the operation unit **5** and which bears no relationship to the magnitude of the load.

A more detailed description of the configuration of the operation lever device **40** is given below.

A piston **41**, correspondent to the direction of the boom lifting operation of the boom operation unit **4**, is provided in the operation lever device **40**, and a pressure-reducing valve **45** is provided correspondent to the piston **41**. In addition, a piston **42** is provided correspondent to the direction of boom lowering operation of the boom operation unit **4**, and a pressure-reducing valve **46** is provided correspondent to the piston **42**. In the same way, a piston **43** is provided correspondent to the dump side operation direction of the bucket operation unit **5**, and a pressure-reducing valve **47** is provided correspondent to the piston **43**. In addition, a piston **44** is provided correspondent to the bucket side operation direction of the bucket operation unit **5**, and a pressure-reducing valve **48** is provided correspondent to the piston **44**.

By the pushdown of the pistons **41**, **42**, **43** and **44** respectively, the set pressure of the pressure-reducing valves **45**, **46**, **47** and **48** are enlarged.

The inlet ports of the pressure-reducing valves **45**~**48** are respectively connected to a pilot hydraulic pump **5** by way of a conduit **16**. In addition, the inlet ports of the pressure-reducing valves **45**~**48** are respectively connected to the tank **14** by way of a conduit **17**.

The outlet ports of the pressure-reducing valves **45**, **46**, **47**, **48** are respectively through connected to the pilot conduits **18**, **19**, **20** and **21**.

Shuttles valves **49**, **50** are provided in the operation lever device **40**.

The pilot conduit **18** is branched into a pilot conduit **18*a*** and pilot conduit **118*b***. In addition, the pilot conduit **19** is branched into a pilot conduit **1 9*a*** and pilot conduit 19*b*.

The pilot conduit **18*b*** and the pilot conduit **20** have through-connection to the inlet ports of the shuttle valve **50**. The outlet port of the shuttle valve **50** has through-connection to the pilot conduit **22**. In the same way, the pilot conduit **19*b*** and pilot conduit **21** have through-connection to the inlet ports of the shuttle valve **49**. The outlet port of the shuttle valve **49** has through-connection to the pilot conduit **23**.

As noted above, the pilot pressured oil is supplied to the operation valve unit **30** from the operation lever device **40** by way of the pilot conduits **18***a,* **19***a,* **22** and **23**.

Next, a description will be given of the working of the above-noted operation lever device **40**.

When the boom operation unit **4** is operated to the boom lifting side the piston **41** is pushed down in accordance with the operation amount S1 and, the pilot pressured oil of pressure P, of a magnitude in accordance with the operation amount S1, is output to the pilot conduit **18** from the pressure-reducing valve **45**.

In the same way, when the boom operation unit **4** is operated to the boom lowering side, the piston **42** is pushed down in accordance with the operation amount S1, and the pilot pressured oil of pressure P, of a magnitude in accordance with the operation amount S1, is output from the pressure-reducing valve **46** to the pilot conduit **19**.

In the same way, when the bucket operation unit **5** is operated to the dump side, the piston **43** is pushed down in accordance with the operation amount S2, and the pilot pressured oil of pressure P, of a magnitude in accordance with the operation amount S2, is output from the pressure-reducing valve **47** to the pilot conduit **20**.

In the same way, when the bucket operation unit **5** is operated to the excavation side, the piston **44** is pushed down in accordance with the operation amount S2, and the pilot pressured oil of pressure P, of a magnitude in accordance with the operation amount S2, is output from the pressure-reducing valve **48** to the pilot conduit **21**.

For this reason, the larger of the pilot pressures P from amongst the pilot pressured oils of pilot pressure P correspondent to the boom lifting side operation amount S1 of the boom operation unit **4**, and of pilot pressure P correspondent to the dump side operation amount S2 of the bucket operation unit **5**, is output from the outlet port of the shuttle valve **50** to the pilot conduit **22** and supplied to the operation valve unit **30**.

In the same way, the larger of the pilot pressures P from amongst the pilot pressured oils of pilot pressure P correspondent to the boom lowering side operation amount S1 of the boom operation unit **4**, and the pilot pressure P correspondent to the excavation side operation amount S2 of the bucket operation unit **5**, is output from the outlet port of the shuttle valve **49** to the pilot conduit **23** and supplied to the operation valve unit **30**.

The pilot pressured oil of pilot pressure P correspondent to the boom lifting operation amount S1 of the boom operation unit **4** is output to the pilot conduit **18***a* to be supplied to the operation valve unit **30**. In addition, the pilot pressured oil of pilot pressure P correspondent to the boom lowering operation valve S1 of the boom operation unit **4** is output to the pilot conduit **19***a* to be supplied to the operation valve unit **30**.

Next, a detailed description of the configuration of the operation valve unit **30** will be given.

The boom operation valve **6** is a control valve which controls the direction and flow rate of the pressured oil discharged from the main hydraulic pump **1** and supplied to the boom hydraulic cylinder **2**.

That is to say, the pressured oil discharged from the main hydraulic pump **1** flows into the boom operation valve **6** by way of a conduit **24** and a branched conduit **24***a* thereof. The pressured oil which has flowed out of the boom operation valve **6** is supplied to the boom hydraulic cylinder **2** by way of conduits **28** or **29**.

The pilot conduits **18***a* and **19***a* are respectively connected to a boom ascend side port **6***d* and a boom descend side port **6***e* of the boom operation valve **6**. The boom operation valve **6** comprises the **3** valve positions **6***c* (neutral position), **6***a* (boom lifting position), and **6***b* (boom lowering position). It will be noted that the valve position of the boom operation valve **6** continually changes, and the opening surface area also continually changes. The opening surface area at the neutral position is 0. When the pilot pressured oil is supplied to the boom ascend side port **6***d* of the boom operation valve **6** by way of the pilot conduit **18***a,* the opening surface area (opening amount) of the boom operation valve **6** changes, becoming **A1**, in response to the pilot pressure P, and the boom operation valve **6** is positioned in the boom lifting position **6***a*. By virtue of this, the pressured oil of flow rate Q1 is, in accordance with the opening surface area **A1**, supplied by way of the conduit **28** and boom operation valve **6** to the bottom chamber **2***a* of the boom hydraulic cylinder **2**. As a result, the boom **10** is actuated to the lifting side.

In addition, when the pilot pressured oil is supplied to the boom descend side port **6***e* of the boom operation valve **6** by way of the pilot conduit **19***a,* the opening surface area (opening amount) A1 of the boom operation valve **6** changes in response to the pilot pressure P, and the boom operation valve **6** is positioned in the boom lowering position **6***b* side. By virtue of this, the pressured oil of flow rate Q1, in accordance with the opening surface area A1, is supplied by way of the conduit **29** to the head chamber **2***b* of the boom hydraulic cylinder **2**. As a result, the boom **10** is actuated to the lowering side.

The return pressured oil from the boom operation valve **6** is discharged to the tank **14** by way of conduits **25***a* or **26***a,* and conduit **25**.

In the same way, the flow rate and direction of the pressured oil output from the main hydraulic pump **1** is controlled by the bucket operation valve **7**, whereby the controlled pressured oil is supplied to the bucket hydraulic cylinder **3**.

That is to say, the pressured oil output from the main pressured oil pump **1** is led to the bucket operation valve **7** by way of the conduit **24** and a branching conduit **24***b* thereof. The pressured oil output from the bucket operation valve **7** is supplied to the bucket hydraulic cylinder **3** by way of conduits **31** or **32**.

The pilot conduits **22**, **23** are respectively connected to a bucket dump side port **7***d* and a bucket excavation side port **7***e* of the bucket operation valve **7**. The bucket operation valve **7** comprises three valve positions **7***c* (neutral position), **7***a* (bucket dump position) and **7***b* (bucket excavation position). It will be noted that the valve position of the bucket operation valve **7** continually changes, and the opening surface area also continually changes. The opening surface area at the neutral position is 0. When the pilot pressured oil is supplied to the bucket dump side port **7***d* of the bucket operation valve **7** by way of the pilot conduit **22**, the opening surface area (opening amount) A2 of the bucket operation valve **7** changes in response to the pilot pressure P, and the bucket operation valve **7** is positioned in the bucket dump position **7***a* side. By virtue of this, the pressured oil of flow rate Q2, in accordance with the opening surface area A2, is supplied to the bottom chamber **3***a* of the bucket hydraulic cylinder **3** by way of the bucket operation valve **7** and a conduit **31**. As a result, the bucket **11** is actuated to the dump side.

In addition, when the pilot pressured oil is supplied to a bucket excavation side port **7***e* of the bucket operation valve

7 by way of the pilot conduit **23**, the opening surface area (opening amount) A2 of the bucket operation valve **7** changes in response to the pilot pressure P, and the bucket operation valve **7** is positioned in the bucket excavation position **7***b* side. By virtue of this, the pressured oil of flow rate Q2, in accordance with the opening surface area A2, is supplied to the head chamber **3***b* of the bucket hydraulic cylinder **3** by way of the bucket operation valve **7** and conduit **32**. As a result, the bucket **11** is actuated to the excavation side.

The return pressured oil from the bucket operation valve **7** is exhausted to the tank **14** by way of the conduit **25***b* or **26***b,* and conduit **25**.

The pressure compensation valve **8** correspondent with the boom operation valve **6** is composed of a flow rate control valve unit **8***a* and pressure-reducing valve unit **8***b*. The pressured oil discharged from the main hydraulic pump **1** flows into the control valve unit **8***a* by way of the conduit **24** and the branching conduit **24***a* thereof The pressured oil discharged from the main hydraulic pump **1** flows into the pressure-reducing valve unit **8***b* by way of the conduit **24** and the branching conduit **24***c* thereof.

Similarly, the pressure compensation valve **9** correspondent with the bucket operation valve **7** is composed of a flow rate control valve unit **9***a* and a pressure-reducing valve unit **9***b*. The pressured oil discharged from the main hydraulic pump **1** flows into the flow rate control valve unit **9***a* by way of the conduit **24** and the branching conduit **24***b* thereof. The pressured oil discharged from the main hydraulic pump **1** flows into the pressure-reducing valve unit **9***b* by way of the conduit **24** and a branching conduit **24***d* thereof.

A pressure in accordance with the maximum load pressure of the hydraulic cylinders **2, 3** is applied in the direction of closure of the pressure-reducing valve units **8***b,* **9***b,* by way of a conduit **27**, on the pressure-reducing valve units **8***b,* **9***b*.

For this reason, the front-to-rear differential pressure ΔP of the operation valves **6, 7** is made the same and constant, by the operation of the pressure compensation valves **8, 9**. By virtue of this, the flow rates Q1, Q2 are established by the opening surface area A1, A2 of the operation valves **6, 7** unrelated to the magnitude of the load of the hydraulic cylinders **2, 3**. In other words, from the above-noted formula (1) ($Q=c\cdot A\cdot\sqrt{(\Delta P)}$), the flow rates Q1, Q2 of the operation valves **6, 7** are, irrespective of load fluctuations, determined univocally in accordance with the opening surface areas (opening amounts) A1, A2 of the operation valves **6, 7**.

An unload valve **12** is provided on the conduit **24**. In the unload valve **12**, the differential pressure between the pressure of the discharged oil of the main pressure pump **1** and the pressure in response to the maximum load pressure of the hydraulic cylinders **2, 3** is, regardless of the fluctuations of the load of the hydraulic cylinders **2, 3**, formed to a constant value in accordance with a set pressure of the unload valve **12**.

The unload valve **12** is opened and closed by: the spring forces of a spring provided in the unload valve **12**; a pressure in response to the maximum load pressure; and the output pressure of the main hydraulic pump **1**. The unload valve **12** is operated to the closing side by the spring and the pressure in response to the maximum load pressure. The unload valve **12** is operated to the opening side by the discharged pressure of the main hydraulic pump **1**. By virtue of this, the differential pressure between the discharged pressure of the main hydraulic pump **1** and the pressure in response to the maximum load pressure is made constant in accordance with the set pressure of the unload valve **12**.

A relief valve **13** is provided in a conduit **27** in which there is action of a pressure in accordance with the maximum load pressure. By virtue of this, the upper limit of the pressure in response to the maximum load pressure is set. Accordingly, the upper limit of the discharged pressure of the main hydraulic pump **1** is established by way of the unload valve **12**.

Furthermore, the boom operation valve **6** and bucket operation valve **7** are configured in such a way that, in the case when the same pilot pressure P has action on the pilot ports **6***d,* **7***d* (or **6***e,* **7***e*), the ratio of the opening surface areas A1, A2 forms a constant ratio (b:a). This constant ratio constitutes the ratio at which the posture of the bucket **11** can be held in the horizontal with respect to the ground surface. More specifically, the ratio of the opening surface areas A1, A2 can be formed to the above-noted constant ratio by the processing of the spool of the boom operation valve **6** and bucket operation valve **7**.

A description is given below, with reference to FIG. **3**, of the relationship between the operation amounts S1, S2 of the operation units **4, 5** and the opening surface areas A1, A2 of the operation valves **6, 7**.

FIG. **3**(*a*) shows the relationship between the lever stroke S1 of the boom operation unit **4** and lever stroke S2 of the bucket operation unit **5**, and the pilot pressure P within the pilot conduits **18***a,* **19***a,* **20** and **21**. The horizontal axis represents the lever stroke S (operation amount S), and the vertical axis represents the pilot pressure P. The characteristics of the boom operation unit **4** are shown by the solid line and the characteristics of the bucket operation unit **5** are shown by the broken line.

When the boom operation unit **4** is operated to the boom lifting side or the bucket operation unit **5** is operated to the dump side, the lever stroke S changes from the neutral position to the right direction in the diagram. As the lever stroke S increases, the pilot pressure P rises. At the point at which the lever stroke S reaches a maximum stroke position Sf, the pilot pressure P reaches a maximum pressure. The characteristics of the operation unit are set in such a way that a maximum pressure PM2, when the bucket operation unit **5** is operated to the dump side, is larger than a maximum pressure PM1, when the boom operation unit **4** is operated to the boom lifting side.

When the boom operation unit **4** is operated to the boom lowering side or the bucket operation unit **5** is operated to the excavation side, the lever stroke S changes from the neutral position to the left direction in the diagram. At identical characteristics, the pilot pressure P rises in response to the increase in the lever stroke S.

FIG. **3**(*b*) shows the relationship between the opening surfaces areas A1, A2 of the boom operation valve **6** and bucket operation valve **7** and the pilot pressure P within the pilot conduits **18***a,* **19***a,* **22** and **23**. The horizontal axis represents the pilot pressure P and the vertical axis represents the opening surface areas A. The characteristics of the boom operation valve **6** are shown by the solid line and the characteristics of the bucket operation valve **7** are shown by the broken line.

When the boom operation unit **4** is operated to the boom lifting side or the bucket operation unit **5** is operated to the dump side, the pilot pressure P changes from the neutral position to the right direction in the diagram. As the pilot pressure P increases, the surface area A rises. At the point at which pilot pressure P reaches a boom maximum pressure PM1, the surface area A1 of the boom operation valve **6** reaches a maximum opening surface area. At the point at which the pilot pressure P reaches a bucket maximum pressure PM2, the surface area A2 of the bucket operation valve **7** reaches a maximum opening surface area.

Here, the characteristics (the spool thereof) of the operation valve **6**, **7** are set in such a way that the ratio of the surface area A2 of the bucket operation valve **7** and the surface area A1 of the boom operation valve **6** are, at the same pilot pressure P, when the boom maximum pressure is PM1 or lower, a constant ratio b:a.

On the other hand, when the boom operation unit **4** is operated to the boom lowering side or the bucket operation unit **5** is operated to the excavation side, the pilot pressure P changes from the neutral position to the left direction in the diagram. With the same operation valve characteristics, the opening surface area A rises in response to the increase in the pilot pressure P.

Next a description will be given of the operation of the hydraulic circuit of the first embodiment of FIG. **1**.

Now, if it is assumed that the operator operates the boom operation unit **4** of the operation lever device **40** to the boom lifting side, the bucket operation unit **5** is not incline-operated from the neutral position.

For this reason, the pilot pressured oil of pilot pressure P is output to the pilot conduit **18***a* in accordance with the operation amount S1 of the boom operation unit **4**. This pilot pressured oil is supplied to the boom ascend side port **6***d* of the boom operation valve **6** by way of the pilot conduit **18***a*.

In addition, the pilot pressured oil of pilot pressure P is output to the pilot conduit **18***b* in accordance with the operation amount S1 of the boom operation unit **4** and applied to one of the inlet ports of the shuttle valve **50**. Now, since the bucket operation unit is in a neutral position, the pressure of the pilot conduit **20**, in other words, the pressure of the other inlet port of the shuttle valve **50**, constitutes the pressure within the tank **14**. For this reason, the pilot pressured oil of pilot pressure P, in accordance with the operation amount S1 of the boom operation unit **4**, is output to the pilot conduit **22** by way of the shuttle valve **50**. The pilot pressured oil is supplied to the dump side port **7***d* of the bucket operation valve **7** by way of the pilot conduit **22**.

For this reason, the boom operation valve **6**, in response to the pilot pressure P applied to the operation valves **6** and **7**, is positioned in the boom rise position **6***a* side, and the bucket operation valve **7** is positioned in the dump position **7***a* side. At this time, as the pilot pressure P increases, lifting is effected while the opening surface area A2 of the bucket operation valve **7** and the opening surface area A1 of the boom operation valve **6** maintain the constant ratio b:a as shown in FIG. **3**(*b*). By virtue of this, lifting is effected while the ratio of the flow rate Q1 supplied to the bottom chamber **2***a* of the boom hydraulic cylinder **2** and the flow rate Q2 supplied to the bottom chamber **3** a of the bucket pressured oil cylinder **3** is maintained at the above-noted constant ration b:a. As a result, accompanying the actuation of the boom **10** to the lifting side, the bucket **11** is actuated to the dump side at a constant relationship, and the posture of the bucket **11** with respect to the ground surface is maintained at the horizontal.

On the other hand, when the operator operates the boom operation unit **4** of the operation lever device **40** to the boom lowering side, in the same way, horizontal control is performed on the bucket **11** to hold it in the horizontal. At this time, the bucket operation unit **5** is not incline-operated from the neutral position.

That is to say, the pilot pressured oil of pilot pressure P is output to the pilot conduit **19***a* in accordance with the operation amount S1 of the boom operation unit **4**. This pilot pressured oil is supplied to the boom descend side port **6***e* of the boom operation valve **6** by way of the pilot conduit **19***a*.

In addition, the pilot pressured oil of pilot pressure P is output to the pilot conduit **19***b* in accordance with the operation amount S1 of the boom operation unit **4** and applied to one of the inlet ports of the shuttle valve **49**. Now, since the bucket operation unit is in a neutral position, the pressure of the pilot conduit **21**, in other words, the pressure of the other inlet port of the shuttle valve **49**, constitutes the pressure within the tank **14**. For this reason, the pilot pressured oil of pilot pressure P is output to the pilot conduit **23** by way of the shuttle valve **49** in accordance with the operation amount S1 of the boom operation unit **4**. The pilot pressured oil is supplied to the excavation side port **7***e* of the bucket operation valve **7** by way of the pilot conduit **23**.

For this reason, the boom operation valve **6**, in response to the pilot pressure P applied to the operation valves **6** and **7**, is positioned in the boom lowering position **6***b* side, and the bucket operation valve **7** is positioned in the excavation position **7***b* side. At this time, as the pilot pressure P increases, lifting is effected while the opening surface area A2 of the bucket operation valve **7** and the opening surface area A1 of the boom operation valve **6** maintain the constant ratio b:a as shown in FIG. **3**(*b*). By virtue of this, lifting is effected while the ratio of the flow rate Q1 supplied to the head chamber **2***b* of the boom hydraulic cylinder **2** and the flow rate Q2 supplied to the head chamber **3***b* of the bucket pressured oil cylinder **3** is maintained at the above-noted constant ration b:a. As a result, accompanying the actuation of the boom **10** to the lowering side, the bucket **11** is actuated to the excavation side at a constant relationship, and the posture of the bucket **11** with respect to the ground surface is maintained at the horizontal.

As noted above, according to the present embodiment, the boom hydraulic cylinder **2** and bucket pressured oil cylinder **3** can be drive simultaneously at a constant flow rate ratio b:a by the simple operation of the boom operation unit **4**, and the posture of the bucket **11** can be held in the horizontal.

In this case, all that is required is for the ratio of the opening amount A1 of the operation valve **6** and the opening amount A2 of the operation valve **7** with respect to the operation amount S1 of the boom operation unit **4** to be set to a constant relationship so, the device configuration, such as the pipe laying of the pressured oil conduits, is simple. That is to say, for example, the new provision of a shuttle valve **50**, **49** and a pilot conduit **18***b*, **19***b* should be performed such that the pilot pressure P can be supplied to the operation valves **6**, **7** in accordance with the operation amount S1. In addition, the operation valves **6**, **7** (the spool) should be configured in such a way that the ratio of the opening amounts A1, A2 of the operation valves **6**, **7** forms a constant relationship.

In addition, according to the present embodiment, all that is required is for the shuttle valve **50**, **49** and the pilot conduit **18***b*, **19***b* to be provided, and for the operation valves **6**, **7** (the spool) to be configured such that the ratio of the opening amount A2 of the bucket operation valve **7** and the opening amount A1 of the boom operation valve **6**, with respect to the operation amount S1 of the boom operation unit **4**, is set to a constant relationship. For this reason, it can be easily installed in existing hydraulic circuits.

In addition, according to the present embodiment, the pilot pressured oil of low pressure and small flow rate is used, so the hydraulic apparatus can be compacted.

As a result, based on the present embodiment, a high versatility can be obtained, the pipe laying can be configured easily and, by the management of the pilot pressured oil, the hydraulic apparatus can be compacted.

In addition, according to the present embodiment, as shown in FIG. **3**, a bucket maximum pressure PM2 is set at a characteristic which is larger than a boom maximum pressure PM1.

For this reason, even if the boom operation unit **4** reaches the maximum stroke position Sf whereby the operation of the boom **10** is mechanically stopped, the bucket **11** can be operated in accordance with the operation amount S2 of the bucket operation unit **5** by the operation of the bucket operation unit **5**.

That is to say, when the bucket operation unit **5** is operated to the dump side and a pilot pressured oil of pilot pressure P, which is larger than the boom maximum pressure PM1, is output to the pilot conduit **20**, a pilot pressured oil of pilot pressure P is output to the pilot conduit **22** in accordance with the operation amount S2 of the bucket operation unit **5** by way of the shuttle valve **50**. In addition, when the bucket operation unit is operated to the excavation side and a pilot pressured oil of pilot pressure P, which is larger than the boom maximum pressure PM1, is output to the pilot conduit **21**, a pilot pressured oil of pilot pressure P is output to the pilot conduit **23** in accordance with the operation amount S2 of the bucket operation unit **5** by way of the shuttle valve **49**. A pilot pressure P in accordance with the operation amount S2 of the bucket operation unit **5** is applied to the dump side port **7***d* or the excavation side port **7***e* of the bucket operation valve **7** by way of the pilot conduits **22** or **23**, and the bucket **11** is actuated to the dump side or excavation side.

Incidentally, the control of the first embodiment constitutes a control whereby, a flow rate of pressured oil, in accordance with the operation amount S1 of the boom operation unit **4**, is supplied to the boom hydraulic cylinder **2** and bucket hydraulic cylinder **3**. For this reason, even following the stroke stoppage of the boom hydraulic cylinder **2** and the stoppage of the operation of the boom **10**, as long as the boom operation unit **4** is operated, the supply of the flow rate of pressured oil to the bucket hydraulic cylinder **3** in accordance with the operation amount S1 thereof is continued, and the bucket **11** continues to be operated. For this reason, the posture of the bucket **11** is not held in the horizontal.

In addition, according the first embodiment, there is a fear that the bucket **11** will be actuated not by the pressured oil supplied from the main hydraulic pump **1** but by its own weight. For this reason, there is a fear that there will be displacement from the horizontal posture of the bucket **11**.

Next, a description will be given of a second embodiment which can resolve these problems.

FIG. **2** shows a hydraulic circuit of a second embodiment. The same reference symbols have been used for the elements which are common with FIG. **1**, and a repetition of the description thereof has been omitted if appropriate.

As is shown in FIG. **2**, a relief valve **33**, which controls the pressure of the pressured oil discharged from the main hydraulic pump **1** to the conduit **24** at a set relief pressure or below, is connected to a branching conduit **24***e* of the conduit **24**. In addition, an unload valve **34** is provided instead of the unload valve **12** of FIG. **1**. It will be noted that, in the hydraulic circuit shown in FIG. **2**, a supplementary circuit has been included in order to afford the actuation of an attachment.

A conduit **25***a,* through which the return pressured oil from the head chamber **2***b* of the boom hydraulic cylinder **2** passes to be exhausted to the tank **14**, is provided in the boom operation valve **6**. In addition, a conduit **26***a,* through which the return pressured oil from the bottom chamber **2***a* of the boom hydraulic cylinder **2** passes to be discharged to the tank **14**, is provided in the boom operation valve **6**. The conduits **25***a,* **26***a* have through-connection to a boom return pressure signal generation conduit **35**. A back pressure valve **25***a* is provided in the conduit **25***a.* For this reason, when the return pressured oil flows through the conduit **25***a* or **26***a* to the tank **14** side, the back pressure valve **80** is operated whereby the return pressured oil back pressure (this is referred to as the boom return pressure signal) is generated within the boom return pressure signal generation conduit **35**.

In the present embodiment, a shuttle valve **50** is incorporated in a selector valve **36**. The pilot conduit **18***b* and pilot conduit **20** are connected to a pressured oil flow inlet on the upstream side of the selector valve **36**. A pilot conduit **22** is connected to the pressured oil flow outlet on the downstream side of the selector valve **36**. The boom return pressure signal generation conduit **35** is connected to the side which opposes the side which a spring for the selector valve **36** is provided. The selector valve **36** comprises a valve position **36***a,* in which the pilot conduits **18***b* and **20** have through-connection to the pilot conduit **22** by way of the shuttle valve **50**, and a valve position **36***b,* in which the pilot conduit **20** has through-connection to the pilot conduit **22**.

When a boom return pressure signal is generated in the boom return pressure signal generation conduit **35**, the boom return pressure signal is applied to the selector valve **36** whereby the selector valve **36** is switched over to the valve position **36***a.* For this reason, the pilot conduit **18***b* and pilot conduit **20** have through-connection with the inlet ports of the shuttle valve **50**. In addition, the outlet ports of the shuttle valve **50** have through-connection with the pilot conduit **22**. On the other hand, when a boom return pressure signal is not generated in the boom return pressure signal generation conduit **35**, the selector valve **36** is switched over to the valve position **36***b* by the spring. For this reason, the pilot conduit **20** has through-connection with the pilot conduit **22**.

In the same way as the selector valve **36**, a selector valve **37**, with a shuttle valve **49** built in, is provided. The pilot conduit **19***b* and pilot conduit **21** are connected to the pressured oil flow inlet on the upstream side of the selector valve **37**. A pilot conduit **23** is connected to the pressured oil flow rate outlet on the downstream side of the selector valve **37**. The above-noted boom return pressure signal generation conduit **35** is connected to the side which opposes the side in which the spring for the selector valve **37** is provided. The selector valve **37** comprises a valve position **37***a,* in which the pilot conduits **19***b* and **21** have through-connection to the pilot conduit **23** by way of the shuttle valve **49**, and a valve position **37***b,* in which the pilot conduit **21** has through-connection to the pilot conduit **23**.

When a boom return pressure signal is generated in the boom return pressure signal generation conduit **35**, the selector valve **37** is switched over to the valve position **37***a* by the application of the boom return pressure signal on the selector valve **37** and the resistance to the spring. For this reason, the pilot conduit **19***b* and pilot conduit **21** have through-connection with the inlet ports of the shuttle valve **49**. In addition, the outlet ports of the shuttle valve **49** have through-connection with the pilot conduit **23**. On the other hand, when a boom return pressure signal is not generated in the boom return pressure signal generation conduit **35**, the selector valve **37** is switched over to the valve position **37***b* by the spring forces. For this reason, the pilot conduit **21** has through-connection with the pilot conduit **23**.

In the present embodiment, a counter-balance valve **39** is built into the valve position **7***d* of the dump side of the bucket operation valve **7**. When the bucket operation valve **7** is positioned in the dump position **7***d,* the conduit **24***b* has through-connection to the conduit **31** by way of a diaphragm **38**. The pressure on the upstream side of the diaphragm **38** is applied to the side opposing the side in which the spring for the counter-balance valve **39** is provided. The counter-balance valve **39** comprises a valve position **39***a,* which obstructs through-connection between the conduit **32** and conduit **25***b,* and a valve position **39***b,* which affords the through-connection between the conduit **32** and conduit **25***b.*

When the pressure of the conduit **24***b* exceeds a certain value, the counter-balance valve **39** is switched over to the valve position **39***b* by the application of the pressure on the upstream side of the diaphragm **38** on the counter-balance valve **39** and the resistance to the spring forces. For this reason, the return pressured oil from the conduit **32** is exhausted to the tank **14** by way of the conduit **25***b*. In addition, when the pressure of the conduit **24***b* is less than the above-noted set value, the counter-balance valve **39** is switched over to the valve position **39***a* by the spring forces. For this reason, the return pressured oil from the conduit **32** is obstructed and the exhausted amount of return pressured oil to the tank **14** is controlled.

Next, a description will be given of the operation of the hydraulic circuit of the second embodiment.

Now, it is assumed that the operator operates the boom operation unit **4** of the operation lever device **40** to the boom lifting side and, at this time, the bucket operation unit **5** is not incline-operated from the neutral position.

For this reason, the pilot pressured oil of pilot pressure P is output to the pilot conduit **18***a* in accordance with the operation amount S1 of the boom operation unit **4**. This pilot pressured oil is supplied to the boom ascend side port **6***d* of the boom operation valve **6** by way of the pilot conduit **18***a*. As a result, the pressured oil is supplied from the boom operation valve **6** to the bottom chamber **2***a* of the boom hydraulic cylinder **2** by way of the conduit **28**. In addition the return pressured oil from the head chamber **2***b* of the boom hydraulic cylinder **2** is caused to flow into the boom return pressure signal generation conduit **35** and conduit **25***a* by way of the boom operation valve **6** and conduit **29**.

The pilot pressured oil of pilot pressure P is output to the pilot conduit **18***b* in accordance with the operation amount S1 of the boom operation unit **4**. Now, since the bucket operation unit **5** is in a neutral position, the pressure of the pilot conduit **20** constitutes the pressure within the tank **14**.

When the boom operation unit **4** has not reached the maximum stroke position Sf, the return pressured oil from the head chamber **2***b* of the boom hydraulic cylinder **2** flows into the conduit **25***a* and boom return pressure signal generation conduit **35**. For this reason, a boom return pressure signal is generated in the boom return pressure signal generation conduit **35**. The boom return pressure signal is applied to the selector valve **36** and the selector valve **36** is switched over to the valve position **36***a*. For this reason, the pilot conduit **18***b* and pilot conduit **20** have through-connection to the inlet ports of the shuttle valve **50**. In addition, the outlet port of the shuttle valve **50** is through connected to the pilot conduit **22**.

For this reason, the pilot pressured oil of pilot pressure P is output to the pilot conduit **22** by way of the shuttle valve **50** in accordance with the operated amount S1 of the boom operation unit **4**. The pilot pressured oil is supplied to the dump side port **7***d* of the bucket operation valve **7** by way of the pilot conduit **22**. As a result, pressured oil is supplied from the boom operation valve **7** to the bottom chamber **3***a* of the bucket pressured oil cylinder **3** by way of the conduit **31**. In addition, the return pressured oil from the head chamber **3***b* of the bucket pressured oil cylinder **3** flows into the bucket operation valve **7** by way of the conduit **32**.

As a result, accompanying the operation of the boom **10** to the lifting side, the bucket **11** is actuated to the dump side at a constant relationship, and the piston of the bucket **11** is maintained horizontal with respect to the ground surface.

When the boom operation unit **4** reaches the maximum stroke position Sf and stroke stoppage of the rod of the boom hydraulic cylinder **2** occurs, the return pressured oil from the head chamber **2***b* of the boom hydraulic cylinder **2** stops flowing into the boom return pressure signal generation conduit **35** and conduit **25***a.* For this reason, the boom return pressure signal stops being generated in the boom return pressure signal generation conduit **35**. For this reason, the selector valve **36** is switched to the valve position **36***b* and the pilot conduit **20** has through-connection to the pilot conduit **22**.

As a result, the pilot pressure P in accordance with the operation amount S1 of the boom operation unit **4** is no longer applied to the boom operation valve **7**. The bucket operation valve **7** forms a state in which work is possible in response to the operation of the bucket operation unit **5**. The bucket operation unit **5** is in a neutral position so, the pilot pressure P is not applied to the boom operation valve **7**. For this reason, at the point at which stroke stoppage of the boom hydraulic cylinder **2** occurs and the operation of the boom **10** is stopped, the supply of pressured oil to the bucket pressured oil cylinder **3** is stopped and the operation of the bucket **11** is stopped. By virtue of this, a state in which the posture of the bucket **11** does not remain in the horizontal is prevented by the continued supply of pressured oil to the bucket hydraulic cylinder **3** after the stroke stoppage of the boom hydraulic cylinder **2** has occurred.

In addition, in a state in which the bucket operation valve **7** is positioned in the dump position **7***d,* when the pressured oil is supplied from the main hydraulic pump **1** to the conduit **24***b,* the pressure within the conduit **24***b* is equivalent to the constant pressure or above. When the pressure on the upstream side of the diaphragm **38**, which constitutes the constant pressure or above, is applied to the counter-balance valve **39**, the counter-balance valve **39** is switched over to the valve position **39***b*. For this reason, the return pressured oil from the bucket pressured oil cylinder **3** is discharged to the tank **14** by way of the conduit **32** and conduit **25***b*. That is to say, when the supplied pressure to the bucket pressured oil cylinder **3** is the constant pressure or above, the exhausted amount of the return pressured oil from the bucket pressured oil cylinder **3** is not controlled.

In addition, when the pressure of the conduit **24***b* is less than the above-noted certain value, the counter-balance valve **39** is switched over to the valve position **39***a*. For this reason, the return pressured oil from the bucket pressured oil cylinder **3** is obstructed by the counter-balance valve **39** and the exhausted amount of the return pressured oil to the tank **14** is controlled. That is to say, when the supplied pressure to the bucket pressured oil cylinder **3** is less than the constant pressure, the exhausted amount of the return pressured oil from the bucket pressured oil cylinder **3** is controlled. By virtue of this, the actuation of the bucket **11** by its own weight is prevented. As a result, the actuation of the bucket

11 by its own weight and the displacement from the horizontal posture is prevented.

Next, a description will be given of a case in which the operator operates the boom operation unit 4 of the operation lever device 40 to the boom lowering side.

That is to say, the pilot pressured oil of pilot pressure P is output to the pilot conduit 19*a* in accordance with the operation amount S1 of the boom operation unit 4. This pilot pressured oil is supplied to the boom descend side port 6*e* of the boom operation valve 6 by way of the pilot conduit 19*a*. As a result, the pressured oil is supplied from the boom operation valve 6 to the head chamber 2*b* of the boom hydraulic cylinder 2 by way of the conduit 29. In addition the return pressured oil from the bottom chamber 2*a* of the boom hydraulic cylinder 2 is caused to flow into the boom return pressure signal generation conduit 35 and conduit 26*a* by way of the boom operation valve 6.

The pilot pressured oil of pilot pressure P is output to the pilot conduit 19*b* in accordance with the operation amount S1 of the boom operation unit 4. Now, since the bucket operation unit 5 is in a neutral position, the pressure of the pilot conduit 21 constitutes the pressure within the tank 14.

When the boom operation unit 4 does not reach the maximum stroke position Sf, the return pressured oil from the bottom chamber 2*a* of the boom hydraulic cylinder 2 flows into the boom return pressure signal generation conduit 35 and conduit 26*a*. For this reason, the boom return pressure signal is generated in the boom return pressure signal generation conduit 35. The boom return pressure signal is applied to the selector valve 37 and the selector valve 37 is switched to the valve position 37*a*. For this reason, the pilot conduit 19*b* and the pilot conduit 21 have through-connection to the inlet ports of the shuttle valve 49. In addition, the outlet port of the shuttle valve 49 has through-connection to the pilot conduit 23.

For this reason, the pilot pressured oil of pilot pressure P is output to the pilot conduit 23 by way of the shuttle valve 49 in accordance with the operation amount S1 of the boom operation unit 4. The pilot pressured oil is supplied to the excavation side port 7*e* of the bucket operation valve 7 by way of the pilot conduit 23. As a result, the pressured oil is supplied to the head chamber 3*b* of the bucket pressured oil cylinder 3 by way of the conduit 32 from the bucket operation valve 7. In addition, the return pressured oil from the bottom chamber 3*a* of the bucket pressured oil cylinder 3 is discharged to the tank 14 by way of the conduit 31 bucket operation valve 7 and conduit 26*b*.

As a result, accompanying the actuation of the boom 10 to the lowering side, the bucket 11 is actuated to the excavation side at a constant relationship, and the posture of the bucket 11 with respect to the ground surface is maintained at the horizontal.

When the boom operation unit 4 reaches the maximum stroke position Sf and stroke stoppage of the rod of the boom hydraulic cylinder 2 occurs, the return pressured oil from the bottom chamber 2*a* of the boom hydraulic cylinder 2 stops flowing into the boom return pressure signal generation conduit 35. and conduit 26*a*. For this reason, the boom return pressure signal stops being generated in the boom return pressure signal generation conduit 35. For this reason, the selector valve 37 is switched to the valve position 37*b* and the pilot conduit 21 has through-connection to the pilot conduit 23.

As a result, the pilot pressure P is no longer applied to the bucket operation valve 7 in accordance with the operation amount S1 of the boom operation unit 4. The bucket operation valve 7 assumes a state in which work is possible in response to the operation of the bucket operation unit 5. The bucket operation unit 5 is in a neutral position so the pilot pressure P is not applied to the bucket operation valve 7. For this reason, at the point at which stroke stoppage of the boom hydraulic cylinder 2 occurs and the operation of the boom 10 is stopped, the supply of pressured oil to the bucket pressured oil cylinder 3 is stopped and the operation of the bucket 11 is stopped. By virtue of this, a state in which the posture of the bucket 11 does not remain in the horizontal is prevented by the continual supply of pressured oil to the bucket hydraulic cylinder 3 following the stroke stoppage of the boom hydraulic cylinder 2.

In the second embodiment described above, the stroke stoppage of the boom hydraulic cylinder 2 is detected by the detection of the pressure of the return pressured oil. However, a means for detection of the stroke stoppage of the boom hydraulic cylinder 2 can be employed as appropriate. By way of example, a limit switch may provided in the boom hydraulic cylinder 2 whereby detection of the stroke stoppage by the use of this limit switch may be performed.

The first embodiment and second embodiment have hypothesized a hydraulic-type operation lever in which the pilot pressured oil of pilot pressure in accordance with the operation amount of the operation lever is output from the operation lever device 40. However, the present invention can also have application in electrical-type lever devices.

FIG. 4 shows a hydraulic circuit of a third embodiment in which an electrical-type operation lever is employed. In the description given below a repetition of the description of the configurative elements which are common to the hydraulic circuit of FIG. 1 has been omitted.

As is shown in FIG. 4, electrical-type operation units 4, 5, which output electrical signals K4, K3, K1 and K2 of a magnitude in accordance with operation amounts S1, S2, are provided in an electrical-type operation lever device 40'.

That is to say, a potentiometer 54 correspondent to the boom lifting side operation direction of the boom operation unit 4 is provided in the operation lever device 40'. In addition, a potentiometer 53 is provided correspondent to the boom lowering side operation direction of the boom operation unit 4. In the same way, a potentiometer 51 is provided correspondent to the dump side operation direction of the bucket operation unit 5. In addition, a potentiometer 52 is provided correspondent to the excavation side operation direction of the bucket operation unit 5.

Electrical signals K4, K3 of a magnitude in accordance with the operation amount S1 of the boom operation unit 4 are respectively output from the potentiometers 54, 53. In the same way, electrical signals K1, K2 of a magnitude in accordance with the operation amount S2 of the boom operation unit 5 are respectively output from the potentiometers 51, 52. The electrical signals K4, K3, K1, K2 are input into a controller 55. Electrical signals PB1, PA1, PB2 and PA2 are output from the controller 55 to electrical signals lines 61, 62, 63, 64.

Pressure-reducing valves 65, 66, 67, 68 are provided in an operation valve unit 30'. The inlet ports of these pressure-reducing valves 65~68 have through-connection to the outlet ports of the pilot hydraulic pump 5 by way of a conduit 17.

A pressure-reducing valve 65 is provided correspondent to the boom ascend side port 6*e* of the boom operation valve 6. The outlet port of the pressure-reducing valve 65 has through-connection to the boom ascend side port 6*d* of the boom operation valve 6 by way of a conduit 18*a*. An electromagnetic solenoid valve 65*a* is provided in the side which opposes the side in which a spring for the pressure-reducing valve **65** is provided. An electrical signal line **61** is connected to the electromagnetic solenoid valve **65***a*. In the same way, a pressure-reducing valve **66** is provided correspondent to a boom descend side port **6***e* of the boom operation valve **6**. The outlet port of the pressure-reducing valve **66** has through-connection to the boom descend side port **6***e* of the boom operation valve **6** by way of the conduit **19***a*. An electromagnetic solenoid valve **66***a* is provided in the side which opposes the side in which a spring for the pressure-reducing valve **66** is provided. An electrical signal line **62** is connected to the electromagnetic solenoid valve **66***a*.

In addition, a pressure-reducing valve **67** is provided correspondent to the bucket dump side port **7***d* of the bucket operation valve **7**. The outlet port of the pressure-reducing valve **67** has through-connection to the bucket dump side port **7***d* of the bucket operation valve **7** by way of the conduit **22**. An electromagnetic solenoid valve **67***a* is provided in the side which opposes the side in which a spring for the pressure-reducing valve **67** is provided. An electrical signal line **63** is connected to the electromagnetic solenoid valve **67***a*. In the same way, a pressure-reducing valve **68** is provided correspondent to the bucket excavation side port **7***e* of the bucket operation valve **7**. The outlet port of the pressure-reducing valve **68** has through-connection to the bucket excavation side port **7***e* of the bucket operation valve **7** by way of the conduit **23**. An electromagnetic solenoid valve **68***a* is provided in the side which opposes the side in which a spring for the pressure-reducing valve **68** is provided. An electrical signal line **64** is connected to the electromagnetic solenoid valve **68***a*.

In order to improve the precision further, the following may also be implemented.

A potentiometer **56** is provided in the boom **10** to detect the actual rotation angle of the boom **10**. A potentiometer **57** is provided in the bucket **11** to detect the actual rotation angle of the bucket **11**. Signals which indicate the angles detected by the potentiometers **56**, **57** are input to the controller **55** by way of the respective electrical signal lines **58**, **59**.

FIG. **5**(*a*) is a diagram which shows the processing details performed by the controller **55** shown in FIG. **4**.

Next, a description will be given of the operation, with reference to the FIG. **5**(*a*), of a third embodiment of FIG. **4**.

Now, it is assumed that the operator operates the boom operation unit **4** of the operation lever device **40'** to the boom lifting side and, at this time, the bucket operation unit **5** is not incline-operated from the neutral position.

The electrical signal K4, in accordance with the operation amount S1 of the boom operation unit **4**, is input into the controller **55** and input into a processing unit **101**. In addition, the electrical signal K1, in accordance with the operation amount S2 of the boom operation unit **5**, is input into the controller **55** and input into the processing unit **101**. The processing unit **101** outputs the largest of the electrical signals K1 , K4. Now, the boom operation unit **4** is incline-operated and the bucket operation unit **5** is in a neutral position so, the electrical signal K4 is larger than the electrical signal K1. For this reason, the electrical signal K4 is output to the processing unit **103** from the processing unit **101** as an electrical signal K5.

In the same way, the electrical signal K3, in accordance with the operation amount S1 of the boom operation unit **4**, is input to the controller **55** and input to a processing unit **102**. In addition, the electrical signal K2, in accordance with the operation amount S2 of the bucket operation unit **5**, is input to the controller **55** and input to the processing unit **102**. The larger of the electrical signals K2, K3 is output as electrical signal K6 by the processing unit **102**.

Electrical signals PB2, PA2 are produced in accordance with a comparison of the magnitudes of the electrical signals K5, K6 by the processing unit **103**.

When KS−K6≧0, the content of the electrical signal PB2 is K5−K6, and the content of the electrical signal PA is 0. In addition, when KS−K6<0, the content of the electrical signal PB2 is 0, and the content of the electrical signal PA is −(KS−K6).

Now, the boom operation unit **4** is not incline-operated to the boom rising side so, the electrical signal K5 is equal to or greater than the electrical signal K6. For this

Now, the boom operation unit **4** is not incline-operated to the boom rising side so, the electrical signal K5 is equal to or greater than the electrical signal K6. For this reason, the electrical signal PB2, which has the content K5−K6, is output from the processing unit **103** to the electrical signal line **63**, and the electrical signal PA2, of content **0**, is output to the electrical signal line **64**.

On the other hand, the electrical signal K4 is output to the electrical signal line **61** as the electrical signal PB1 in accordance with the operation amount S1 of the boom operation unit **4**.

For this reason, the electrical signal PB1, of a magnitude in accordance with the operation amount S1 of the boom operation unit **4**, is applied to the electromagnetic solenoid valve **65***a* of the pressure-reducing valve **65** by way of the electrical signal line **61**. The pilot pressured oil is pressure reduced to a magnitude in accordance with the electrical signal PB1 by the pressure-reducing valve **65**. The pilot pressured oil of pilot pressure P, in accordance with the electrical signal PB1, is supplied to the boom ascend side port **6***d* of the boom operation valve **6** by way of the pilot conduit **18***a*.

In addition, the electrical signal PB2, of a magnitude in accordance with the operation amount S1 of the boom operation unit **4**, is applied to the electromagnetic solenoid valve **67***a* of the pressure-reducing valve **67** by way of the electrical signal line **63**. The pilot pressured oil is pressure reduced to a magnitude in accordance with the electrical signal PB2 by the pressure-reducing valve **67**. The pilot pressured oil of pilot pressure P, in accordance with the electrical signal PB2, is supplied to the dump side port **7***d* of the bucket operation valve **7** by way of the pilot conduit **22**.

For this reason, the boom operation valve **6**, in accordance with the pilot pressure P applied to the operation valves **6**, **7**, is positioned in the boom rising position **6***a* side, and the bucket operation valve **7** is positioned in the boom rise position **7***a* side. At this time, as the pilot pressure P increases, lifting is effected while the ratio of the opening surface area A1 of the boom operation valve **6** and the opening surface area A2 of the bucket operation valve **7** is maintained at the constant ratio b:a as shown in FIG. **3**(*b*). By virtue of this, lifting is effected while the ratio of the flow rate Q1 supplied to the bottom chamber **2***a* of the boom hydraulic cylinder **2** and the flow rate Q2 supplied to the bottom chamber **3***a* of the bucket pressured oil cylinder **3** are maintained at an unaltered constant ratio of b:a. As a result, accompanying the operation of the boom **10** to the rising side, the bucket **11** is actuated to the dump side at a constant relationship, and the posture of the bucket **11** with respect to the ground surface is held in the horizontal.

On the other hand, when the operator operates the boom operation unit **4** of the operation lever device **40'** to the boom lowering side, in the same way, horizontal hold control is performed which holds the bucket **11** in the horizontal.

That is to say, as shown in the processing unit **103** of FIG. **5**(*a*), now, the boom operation unit **4** is incline-operated to the boom lowering side so K−K**6**<0. For this reason, the electrical signal PB**2**, of the content **0**, is output from the processing unit **103** to the electrical signal line **63**, and the electrical signal PA**2** of the content −(K**5**−K**6**) is output to the electrical signal line **64**.

On the other hand, the electrical signal K**3** is output to the electrical signal line **62** as the electrical signal PA**1** in accordance with the operation amount S**1** of the boom operation unit **4**.

For this reason, the electrical signal PA**1**, of a magnitude in accordance with the operation amount S**1** of the boom operation unit **4**, is applied to the electromagnetic solenoid valve **66***a* of the pressure-reducing valve **66** by way of the electrical signal line **62**. The pilot pressured oil is pressure reduced to a magnitude in accordance with the electrical signal PA**1** by the pressure-reducing valve **66**. The pilot pressured oil of pilot pressure P in accordance with the electrical signal PA**1** is supplied to the boom lowering side port **6***e* of the boom operation valve **6** by way of the pilot conduit **19***a*.

In addition, the electrical signal PA**2**, of a magnitude in accordance with the operation amount S**1** of the boom operation unit **4**, is applied to the electromagnetic solenoid valve **68***a* of the pressure-reducing valve **68** by way of the electrical signal line **64**. The pilot pressured oil is pressure reduced to a magnitude in accordance with the electrical signal PA**2** by the pressure-reducing valve **68**. The pilot pressured oil of the pilot pressure P in accordance with the electrical signal PA**2** is supplied to the excavation side port **7***e* of the bucket operation valve **7** by way of the pilot conduit **23**.

For this reason, the boom operation valve **6**, in accordance with the pilot pressure P applied to the operation valves **6**, **7**, is positioned in the boom lowering position **6***b* side, and the bucket operation valve **7** is positioned in the excavation position **7***b* side. At this time, as the pilot pressure P increases, lifting is effected while the ratio of the opening surface area A**1** of the boom operation valve **6** and the opening surface area A**2** of the bucket operation valve **7** is maintained at the constant ratio b:a as shown in FIG. **3**(*b*). By virtue of this, lifting is effected while the ratio of the flow rate Q**1** supplied to the bottom chamber **2***a* of the boom hydraulic cylinder **2** and the flow rate Q**2** supplied to the bottom chamber **3***a* of the bucket pressured oil cylinder **3** are maintained at the unaltered constant ratio of b:a. As a result, accompanying the operation of the boom **10** to the rising side, the bucket **11** is actuated to the excavation side at a constant relationship, and the posture of the bucket **11** is held in the horizontal with respect to the ground surface.

Signals which indicate the actual angle of the boom **10** and bucket **11** are input to the controller **55** by way of electrical signal lines **58**, **59**. Thereupon, the angle signal, as a feedback signal, may be controlled in such a way that the actual angle of the boom **10** and bucket **11** matches a target angle. The posture of the bucket **11** with respect to the ground surface can be more precisely held in the horizontal by the matching of the actual angle of the boom **10** and bucket **11** to the target angle.

A variety of modifications to the third embodiment described above are possible.

In FIG. **4**, the operation valves **6**, **7** are caused to operate by the provision of pressure-reducing valves **65**~**68**, and the conversion of the electrical signals PB**1**, PA**1**, PB**2** and PA**2** to pilot pressure to be supplied to the operation valves **6**,**7**. However, the operation valves **6**, **7** may be worked by the configuration of the operation valves **6**, **7** as electromagnetic proportion control valves and the direct application of the electrical signals PB**1**, PA**1**, PB**2** and PA**2** on the operation valves **6**, **7**.

In addition, a processing unit **103**' as shown in FIG. **5**(*b*) may be adopted instead of the processing unit **103** of FIG. **5**(*a*). Using the processing unit **103**', the electrical signal K**5** is output to the electrical signal line **63** as an electrical signal PB**2** and the electrical signal K**6** is output to the electrical signal line **64** as an electrical signal PA**2**.

In the first, second and third embodiments described above, the posture of the bucket **11** is automatically held in the horizontal in response to both the rise and lowering operations of the boom **10**. Next, a description will be given of a embodiment in which the bucket **11** posture can be automatically held in the horizontal when an operation which affords the rise only of the boom **10** is performed.

FIG. **6** shows the hydraulic circuit of the embodiment of FIG. **4**. Representation of the configurative elements which are common to FIG. **1** have been omitted in FIG. **6**. In addition, the same reference symbols have been used for the same configurative elements common to FIG. **1** and a repetition of the description thereof has been omitted.

As is shown in FIG. **6**, the operation lever device **40**" is composed of a boom operation unit **4** and bucket operation unit **5**.

A circuit for holding the bucket horizontal **70** is provided on the conduit between the bucket operation unit **5** and bucket operation valve **7**.

The circuit for holding the bucket horizontal **70** is mainly composed of control valves **71**, **73** and shuttle valves **72** and **74**. The control valve **71** comprises a valve position **71***a*, in which there is through-connection of a pilot conduit **18***b* with one of the inlet ports of the shuttle valve **72**, and a valve position **71***b*, in which there is obstruction of the through-connection of the pilot conduit **18***b* with the other inlet port of the shuttle valve **72**.

The other inlet port of the shuttle valve **72** has through-connection to the pilot conduit **20**.

The outlet port of the shuttle valve **72** has through-connection to the pilot conduit **22**.

A pilot port **71***c* is provided in the side in which the spring of the control valve **71** is provided. The pilot conduit **20** has through-connection to the pilot port **71***c*. In addition, a pilot port **71***d* is provided in the side opposing the pilot port **71***c* of the control valve **71**. The pilot conduit **21** has through-connection to the pilot port **71***d*.

In the same way, the control valve **73** comprises a valve position **73***a*, in which there is through-connection of a pilot conduit **19***b* with the one of the inlet ports of the shuttle valve **74**, and a valve position **73***b*, in which there is obstruction of the through-connection of the pilot conduit **19***b* with the other inlet port of the shuttle valve **74**.

The other inlet port of the shuttle **74** has through-connection to the pilot conduit **21**.

The outlet port of the shuttle **74** has through-connection to the pilot conduit **23**.

A pilot port **73***c* is provided in the side in which a spring for the control valve **73** is provided. The pilot conduit **21** has through-connection to the pilot port **73***c*. In addition, a pilot port **73***d* is provided in the side opposing the pilot port **73***c* of the control valve **73**. The pilot conduit **20** has through-connection to the pilot port **73***d*.

A description will be given of the workings of the fourth embodiment.

Now, it is assumed that the operator operates the boom operation unit **4** of the lever operation device **40**" to the boom lifting side. At this time, the bucket operation unit **5** is not incline-operated from the neutral position.

For this reason, the pilot pressured oil of pilot pressure P is output to the pilot conduit **18***a* in accordance with the operation amount S1 of the boom operation unit **4**. This pilot pressured oil is supplied to the boom ascend side port **6***d* of the boom operation valve **6** by way of the pilot conduit **18***a*.

In addition, the pilot pressured oil of the pilot pressure P is output to the pilot conduit **18***b* in accordance with the operation amount S1 of the boom operation unit **4**.

Now, since the bucket operation unit **5** is in a neutral position, the pressure is not applied to the pilot ports **71***c*, **71***d* of the control valve **71** by way of the pilot conduits **20**, **21**. For this reason, the control valve **71** is positioned, by the spring forces, in the valve position **71***a*. For this reason, the pilot conduit **18***b* has through-connection to one of the inlet ports of the shuttle valve **72**. Now, since the bucket operation unit **5** is in a neutral position, the pressure of the pilot conduit **20**, in other words, the pressure of the other inlet port of the shuttle valve **72**, constitutes the pressure within the tank **14**. For this reason, the pilot pressured oil of pilot pressure P, in accordance with the operation amount S1 of the boom operation unit **4**, is output to the pilot conduit **22** by way of the shuttle valve **72**. The pilot pressured oil is supplied to the dump side port **7***d* of the bucket operation valve **7** by way of the pilot conduit **22**.

For this reason, the boom operation valve **6**, in response to the pilot pressure P applied to the operation valves **6**, **7**, is positioned in the boom rising position **6***a* side, and the bucket operation valve **7** is positioned in the dump position **7***a* side. At this time, as the pilot pressure P increases, lifting is effected while the ratio of the opening surface area A2 of the bucket operation valve **7** and the opening surface area A1 of the boom operation valve **6** is maintained at a constant ratio b:a as shown in FIG. **3**(*b*). By virtue of this, lifting is effected while the ratio of the flow rate Q1 supplied to the bottom chamber **2***a* of the boom hydraulic cylinder **2** and the flow rate Q2 supplied to the bottom chamber **3***a* of the bucket pressured oil cylinder **3** is maintained at the above-noted unaltered constant ratio b:a. As a result, accompanying the operation of the boom **10** to the lifting side, the bucket **11** is actuated to the dump side at a constant relationship, and the posture of the bucket **11** with respect to the ground surface is maintained at the horizontal.

When the bucket operation unit **5** is operated to the excavation side, the pilot pressure of the pilot conduit **21** is applied to the pilot port **71***d* of the control valve **71**. As a result, the control valve **71** is positioned in the valve position **71***b*. For this reason, the through-connection between the pilot conduit **18***b* and one of the inlet ports of the shuttle valve **72** is obstructed. By virtue of this, the bucket operation valve **7** stops operating in response to the operation of the boom operation unit **4**.

The pilot pressure within the pilot conduit **21** is applied to the excavation side port **7***e* of the bucket operation valve **7**. For this reason, the bucket operation valve **7** is operated in response to the operation of the bucket operation unit **5** and, in response thereto, the bucket **11** is operated.

When the operator operates the boom operation unit **4** of the operation lever device **40**" to the boom lowering side, the control valve **73** and shuttle valve **74** are operated in the same way as the control valve **71** and shuttle valve **72**. By virtue of this, accompanying the operation of the boom **10** to the downward side, at a constant relationship, the bucket **11** is operated to the excavation side, and the posture of the bucket **11** is held horizontal with respect to the ground surface.

In the embodiments described above, a description has been given in which horizontal hold control of the posture of the bucket **11** with respect to the ground surface is hypothesized. However, the present invention is not limited to the horizontal posture and can have application provided the posture of the bucket **11** is to be held constant.

In addition, in the embodiments described above, an embodiment has been hypothesized in which the posture of the work device **11** is controlled to a constant posture by the control of the flow ratio of two hydraulic actuators **2**, **3** to a constant ratio. However, the range of application of the present invention is in no way limited to a case in which the posture of the work device in the work machine is controlled to a constant posture. The present invention, without limitation to work machine, can have application in a wide range of hydraulic drive machines in which the flow rate ratio of two hydraulic actuators is controlled to a constant ratio.

What is claimed is:

1. An actuator control device for a hydraulic drive machine which comprises:

- a hydraulic pump and at least two hydraulic actuators driven by supply of discharged pressured oil from the hydraulic pump;
- an operation means each provided correspondent with each hydraulic actuator; and
- an operation valve connected between each of the operation means and each of its correspondent hydraulic actuator, each operation valve changing its respective opening amount in accordance with an operating amount of each operation means, and which supply pressured oil to the hydraulic actuators correspondent with the operation means, at a flow rate according to the respective opening amount, wherein,
- the actuator control device further comprises:
  - front-to-rear differential pressure constant means connected between the hydraulic pump and each of the operation valves which equalize a difference in pressure between a pressure of pressured oil on an upstream side and a pressure of pressured oil on a downstream side of each of the operation valves, and wherein,
- when one of the operation means is operated, by changing the opening amount of the other one of the operation valves correspondent with the other one of the operation means in accordance with the operation amount of said one of the operation means, the other one of the hydraulic actuators correspondent with said other one of the operation valves is driven.

2. A bucket posture control device for a hydraulic drive machine which comprises:

- a hydraulic pump, and a boom hydraulic actuator and a bucket hydraulic actuator driven by supply of discharged pressured oil from the hydraulic pump;
- a boom and a bucket operated in accordance with the drive of the boom hydraulic actuator and the bucket hydraulic actuator respectively;
- boom operation means and bucket operation means provided correspondent with the boom hydraulic actuator and the bucket hydraulic actuator respectively; and
- a boom operation valve and a bucket operation valve which change opening amounts thereof in accordance

with operating amounts of the boom operation means and the bucket operation means respectively, and which supply pressured oil to the boom hydraulic actuator and the bucket hydraulic actuator respectively, at a flow rate in accordance with the respective opening amounts, wherein

the bucket posture control device further comprises:

front-to-rear differential pressure constant means connected between the hydraulic pump and each of the operation valves which equalize a difference in pressure between a pressure of pressured oil on an upstream side and a pressure of pressured oil on a downward side of the boom operation valve and the bucket operation valve respectively and,

control means which, when the boom operation means is operated, changes the opening amount of the bucket operation valve in accordance with the operation amount of the boom operation means in such a way that a posture of the bucket is held constant.

3. A bucket posture control device for a hydraulic drive machine which comprises:

a hydraulic pump, and a boom hydraulic actuator and a bucket hydraulic actuator driven by supply of discharged pressured oil from the hydraulic pump;

a boom and a bucket operated in accordance with the drive of the boom hydraulic actuator and the bucket hydraulic actuator respectively;

boom operation means and bucket operation means provided correspondent with the boom hydraulic actuator and the bucket hydraulic actuator respectively, and

a boom operation valve and a bucket operation valve which change opening amounts thereof in accordance with operating amounts of the boom operation means and the bucket operation means respectively, and which supply pressured oil to the boom hydraulic actuator and the bucket hydraulic actuator respectively, at a flow rate in accordance with the respective opening amounts, wherein

the bucket posture control device further comprises:

front-to-rear differential pressure constant means connected between the hydraulic pump and each of the operation valves which equalize a difference in pressure between a pressure of pressured oil on an upstream side and a pressure of pressured oil on a downward side of the boom operation valve and the bucket operation valve respectively and,

control means which, when a boom operation signal is output from the boom operation means to afford a lift operation of the boom, generates a bucket operation signal which affords the actuation of the bucket in a dumping direction in response to the boom operation signal, and changes the opening amount of the bucket operation valve in response to the bucket operation signal in such a way that a posture of the bucket is held constant.

4. The bucket posture control device for the hydraulic drive machine as claimed in claim **2**, further comprising stroke stoppage detection means connected to the boom operation valve which detects a stroke stoppage of the boom hydraulic actuator, wherein, when the stroke stoppage of the hydraulic actuator has been detected by the stroke stoppage detection means, the control by the control means is turned off.

5. The bucket posture control device for the hydraulic drive machine as claimed in claim **2**, further comprising exhaust flow rate control means connected to the bucket operation valve for controlling, in response to the pressure of the pressured oil supplied to the bucket hydraulic actuator, a flow rate of the pressured oil exhausted from the bucket hydraulic actuator in such a way that the posture of the bucket is held constant.

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